STANGER

Heat of Dilution of Cane Sugar Solutions

Chemistry

B. S.

1909

Heat of Dilution of Cane Sugar Solutions

by

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Thesis for the Degree of Bachelor of Science

in Chemistry

in the

College of Science

of the

University of Illinois.

Presented June 1909.

UNIVERSITY OF ILLINOIS

May 29 1909

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

O. C. Stanger

ENTITLED Heat of Dilution of Cane Sugar Solutions.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science

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Instructor in Charge.

APPROVED: W. A. Noyes

HEAD OF DEPARTMENT OF Chemistry

HEAT OF DILUTION

OF CANE SUGAR SOLUTIONS.

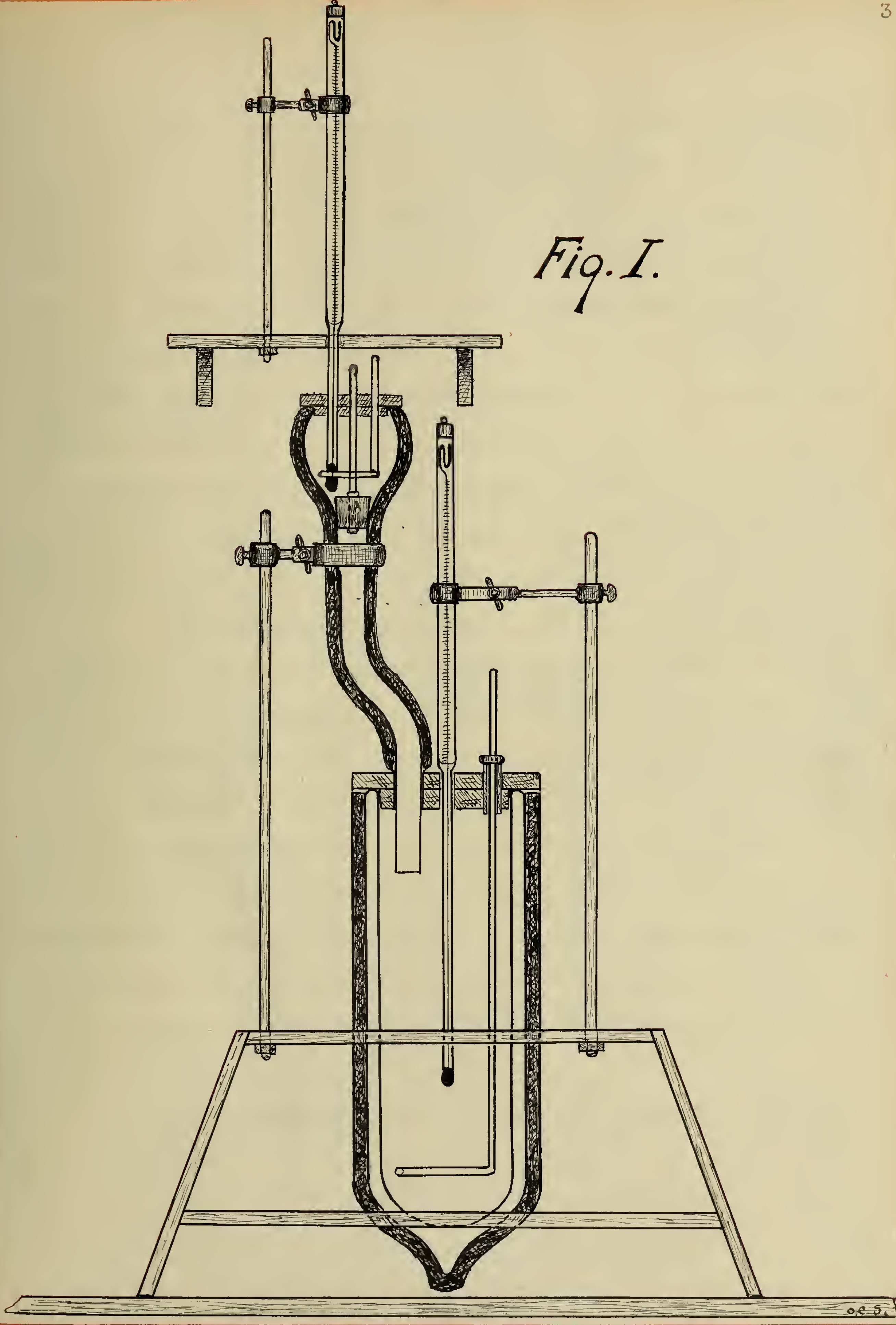
The problem of the heat effects produced by the dilution of cane sugar solutions has not received very much attention from investigators. Some work has appeared in the literature bearing on this line. Von Stackelberg (Zeit. Phys. Chem., 26, 546, 1898), gives values for heats of dilution of many inorganic substances, with but meager data relating to cane sugar solutions. Ewan, (Zeit. Phys. Chem., 14, 422, 1894, and 22, 1899), in his endeavor to throw additional light on the relation between the osmotic pressure and concentration of solutions has made a series of determinations of heat dilution of cane sugar at various concentrations, but at only one temperature.

Whether or not the values for the heat dilution are influenced by temperature at which the experiments are carried on does not seem to have been considered in any previous work. Up to the present time no attempt has been made to determine the value of the heat of dilution and subsequently the temperature coefficient when both the concentration and the temperature were varied. It is therefore the purpose of this paper to present data relating to the heat of dilution of cane sugar solutions under varying concentrations and for a range of temperatures.

The first problem was to devise a form of calorimeter which would enable accurate measurements of heat effects. The use of a Dewar bulb was here suggested. It seemed apparent that a Dewar bulb ought to give good results owing to the vacuum chamber, which would cut down the rate of radiation. This is a very important factor, since the quantities of heat to be measured would be very small and the error must needs be reduced as much as possible to obtain sufficient accuracy.

A Dewar bulb of about 8 cm. inside diameter, about 30 cm. high and a capacity of about 900 cc. was procured. Several experiments relative to the rate of radiation were carried out. The particular bulb employed was not one of the silvered variety and it was found that the rate of radiation was about .06° per minute with a difference of 10° from room temperature. In order to reduce this radiation the outside of the bulb was covered with a layer of smooth tinfoil, which was pasted on by means of a solution of water glass. The bulb was then enclosed in a sheath of hair felt an inch thick. Further experiments showed that the rate of radiation had been thus reduced to from .005° to .008° per minute, depending somewhat on the temperature difference from the room temperature. The bulb was then mounted in a wooden frame as shown in Fig. I, and covered with a thick cork stopper, through which a Beckmann thermometer, a glass stirrer and a delivery tube from the upper container were passed. This upper container consisted of a

Fig. I.



250 cc. flask with the bottom cut off, to the neck of which a tube was fitted, which in turn was somewhat bent to clear the lower thermometer. This flask and delivery tube were then wrapped in hair felt and covered with a layer of asbestos. The rate of radiation of this container was determined and was found to be about 0.02° per minute. This value again depending upon the room temperature. A rubber stopper with a glass rod through it was fitted into the neck of the flask to serve as a valve. A stirrer and a Beckmann thermometer were placed into this upper container. The whole apparatus was then set up as shown in Fig. I.

The Beckmann thermometers were set at the required temperature and their difference in degrees recorded so that both could be corrected to the same standard temperature. The whole apparatus was then placed in a constant temperature room in the basement. Here data was collected at 0°, 5°, 10°, 15°. The 25° experiment was carried out in the laboratory upstairs. This room could be kept within a few degrees of the temperature at which the experiment was carried on and thus the radiation was reduced. Owing to the mild winter and the absence of any means of artificial cooling it was difficult to obtain much data at 0 degrees.

The experiments were carried out according to the following plan:

Grams of Sugar	Dissolved in — grams of Water	Diluted with — grams of Water
I a b 171	500	200
II a b 188.1	550	150
III a b 205.2	600	100

Different amounts of solvent were added to see whether or not the total heat of dilution had been measured.

The sugar used was of the "Domino" variety and was not purified. Both the water and sugar were weighed out.

After the sugar had been dissolved, both the sugar solution and the water were brought to within 0.5° of the particular temperature at which the experiment was to be conducted and were placed into their respective containers, the water above, the sugar solution below. The whole apparatus was then allowed to remain for from ½ to 1 hour to become constant. Both thermometers were then read every minute for eight minutes. The plan adopted was this: the lower thermometer was read on the minute and the upper on the half minute, thus giving one-half minute between each reading and allowing ample time for stirring. The thermometers were graduated to hundredths of a degree, and could be read to .001° by means of a glass. The liquids were stirred before each reading by a definite amount, this stirring being kept constant for all determinations. One-half minute

after the last upper reading was taken the stopper was pulled from the upper flask and the water allowed to drop into the sugar solution below. Minute readings for from 10 to 15 minutes were taken. The mixture was stirred by the same definite amount as before. Each experiment was carried out in duplicate.

The constant that is the heat capacity of the calorimeter was determined from data collected by mixing water at different temperatures.

Results.

The temperatures were tabulated and curves plotted to obtain the exact temperature of each liquid at the time of mixing. The final temperature of the mixture was calculated from the series of temperatures of the mixture. The temperatures of the upper thermometer were, in each case, corrected to those of the lower by adding or subtracting the difference between the two thermometers. The calculation of the heat effect was carried out according to the following formula:

$$Q = Aa\ (t_3 - t_1) + (Bb + K)(t_3 - t_2).$$

Where

Q = heat evolved in colories

A = amount of water in upper flask

a = specific heat of same

B = amount of sugar solution in Dewar

b = specific heat of same

t_1 = temperature of upper flask at time of mixing

t_2= temperature of lower bulb at time of mixing

t_3= final temperature of mixture.

K = constant of calorimeter

$\frac{Q}{A}$ = q = heat evolved per g. of solvent added, which is the temperature coefficient.

The values for the specific heat of cane sugar solution were obtained by taking known values and plotting a curve and taking the required values from the curve. A summary of the data will be found in Table 1.

The most striking thing about the data is the fact that the temperature coefficient at 5° is negative. There is no apparent reason for this peculiarity and further investigation would be required to determine whether it is due to experimental error or to some phenominon. The total experimental error due to the temperature readings would never exceed .005°. The only other source which could account for this abnormality would be a possible mistake in the comparison of the thermometers. The original data was checked over and no error was found. Further evidence which would indicate that these values are not negative is the fact that the two determinations made at 0 degrees are positive, but here again more data is necessary to enable one to draw definite conclusions. If, now, the results at 5° are not taken into consideration it will be seen that the effect of temperature on the heat of dilution and the temperature coefficient must be very small if not exactly zero, and could be neglected.

0°	10°	15°	25°
+.06 col.	+.14 col.	+.10 col.	+.09 col.

The above table shows that there is no regular change in the value for the temperature coefficient with the temperature and it has evidently no effect. Assuming that the negative values are due to some error or abnormality the positive values alone were averaged. The average of 15 gave .11 calories, with an average deviation of .04 calories.

According to Lewis, (J. A. C. S., May, 1908), "since the freezing point method affords a method of determining the osmotic pressure at the freezing point it is possible to determine the osmotic pressure at other temperatures if we knew the temperature coefficient", by making use of the following thermodynamic equation.

$$\pi - q = T \frac{d\pi}{dT}$$

where π is the osmotic pressure, T the absolute temperature, and q the heat of dilution per gram of solvent added to a large quantity of solution. If, now, the value for q at various temperatures is known or if change in temperature has little or no influence, the osmotic pressure can be calculated for any temperature.

The average value for q found by <u>von Stockelberg</u> and <u>Ewen</u> is .12 col. or 5 cc. atmospheres. The average value from the data in this paper is .11 calories, or 4.5 cc. atmospheres, and includes values for a range of temperatures. The error due to the average deviation, .04 cal. or 1.6 cc. atmospheres, would be $\pm\frac{1.6}{273 + t}$ or about 0.6% at 0 degrees and would decrease as t increased.

0°							Table I.	
No	Grams Sugar	In Grams Water	Diluted with g. water.	t_1	t_2	t_3	Q in cal	q in cal
I O (a)	171.0	500	200	3.212°	3.050°	3.097°	+ 6.55	.037
I O (b)	171.0	500	200	3.139°	3.103°	3.124°	+ 11.54	.077
				5°				
I A (a)	171.0	500	200	4.010°	3.159°	3.342°	− 19.64	− .098
" (b)	171.0	500	200	4.056	3.295	3.445	− 28.66	− .143
II A (a)	188.1	550	150	2.451	1.999	2.047	− 28.88	− .193
" " (b)	188.1	550	150	3.640	3.016	3.123	− 4.95	− .033
III A (a)	205.2	600	100	2.526	2.263	2.281	− 11.25	− .113
" " (b)	205.2	600	100	3.610	2.861	2.930	− 12.04	− .120
				10°				
I B (a)	171	500	200	1.735°	1.471°	1.683°	+ 22.10	+ .111
" " (b)	171	500	200	1.626	1.478	1.565	+ 32.74	+ .169
II B. (a)	188.1	550	150	1.670	1.260	1.365	+ 24.74	+ .165
II " (b)	188.1	550	150	1.649	1.341	1.423	+ 22.26	+ .148
III B (a)	205.2	600	100	1.659	1.214	1.283	+ 12.85	+ .129
III " (b)	205.2	600	100	1.716	1.290	1.360	+ 13.66	+ .137
				15°				
I C (a)	171.0	500	200	1.223°	1.256°	1.460°	—	—
I C (b)	171.0	500	200	1.176	1.275	1.258°	− .818	− .004?
II C (a)	188.1	550	150	1.310	1.320	1.335°	+ 14.02	+ .093
II C (b)	188.1	550	150	0.746	1.117	0.981	+ 20.72	+ 0.158
III C (a)	205.2	600	100	1.053	1.194	1.199	+ 8.03	+ 0.08
III C (b)	205.2	600	100	1.241	0.955	0.997	+ 5.62	+ 0.056
				25°				
I D (a)	171.0	500	200	2.375°	1.781°	1.956°	+ 22.93	+ 0.115
I D (b)	171.0	500	200	3.744	2.735	3.003	+ 19.74	+ 0.099
II D (a)	188.1	550	150	5.105	4.013	4.222	+ 8.25	+ 0.055

Average of + values = 0.11 cal.

Average Deviation = 0.04 cal.

Water Equivalent of Calorimeter

200g Water above
500g Water below.

(a)

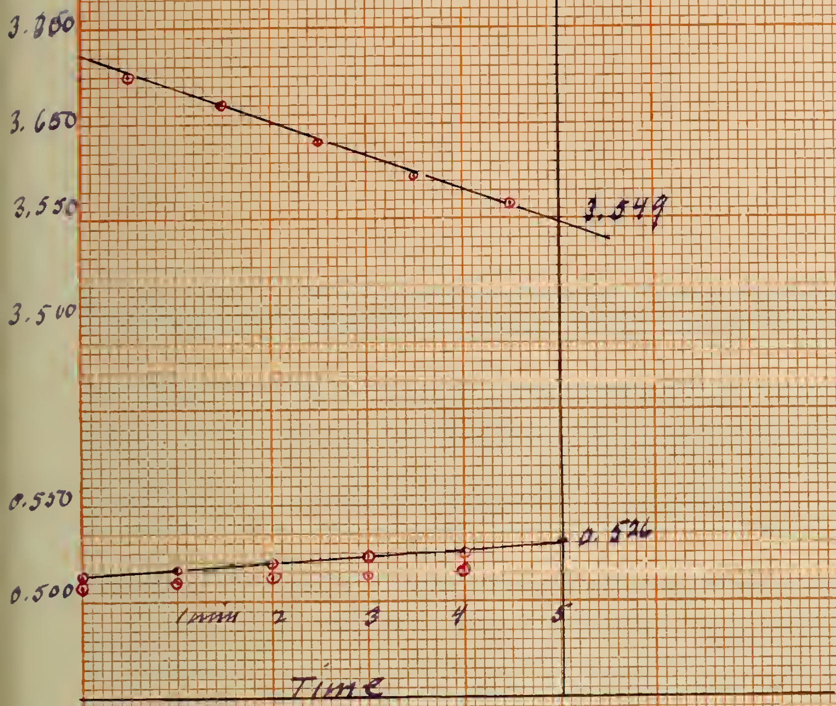
Upper Flask	Lower Dewar.
4.076° C	0.555° C
4.048° "	0.554° "
4.026° "	0.554° "
3.996° "	0.555° "
3.988° "	0.556° "
3.976° "	0.557° "
3.956° "	0.559° "
3.943° "	0.561° "

Mixture.	1.475° "
	1.455° "
	1.452° "
	1.452° "
	1.452° "
	1.451° "
	1.450° "
	1.449° "
	1.448° "
	1.448° "
	1.447° "

(b)

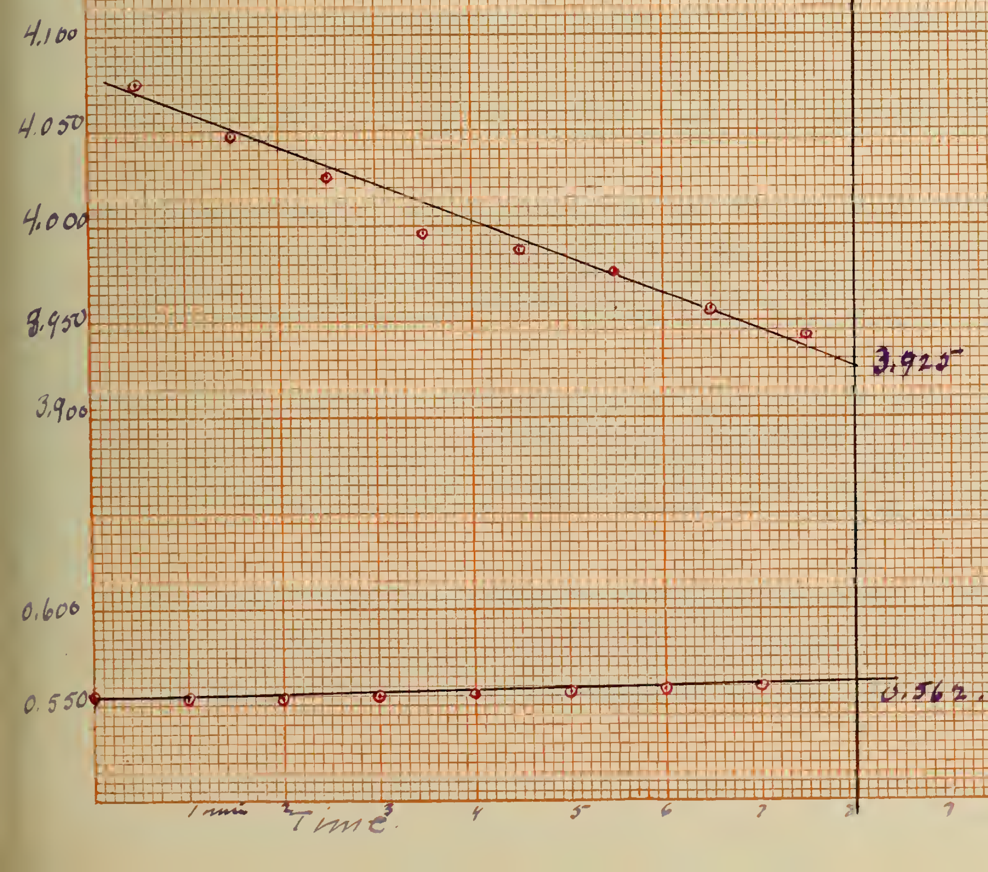
Upper Flask.	Lower Dewar.
3.626° C	0.515° C
3.611° "	0.518° C
3.591° "	0.520° "
3.574° "	0.522° "
3.557° "	0.524° "

Mixture.	1.330° "
	1.330° "
	1.330° "
	1.329° "
	1.327° "
	1.325° "
	1.323° "
	1.320° "
	1.318° "
	1.315° "



Curves for
Constant of
the
Calorimeter
or
Water Equivalent.

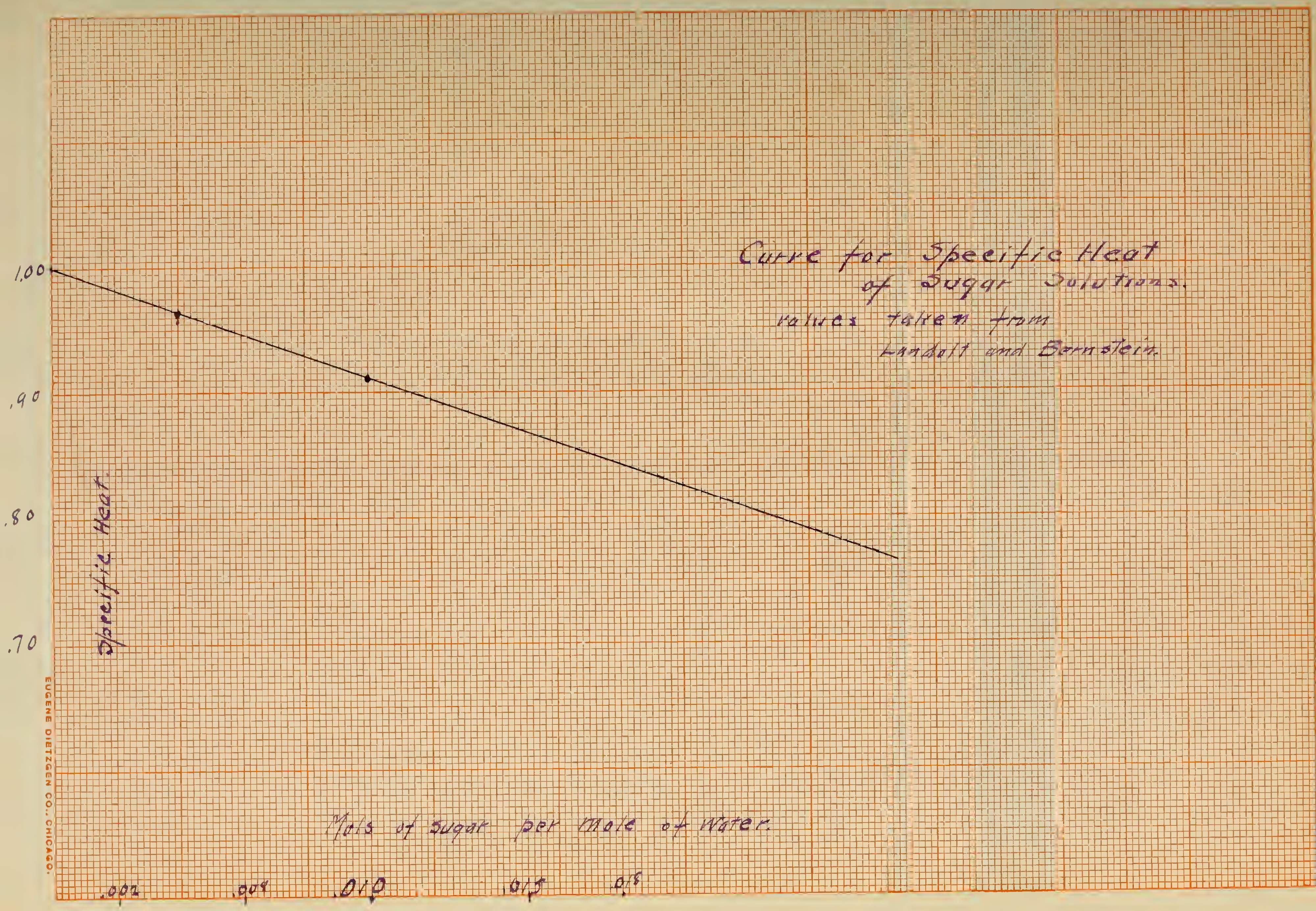
50.3 cal.



54.0 cal.

Average = 52.

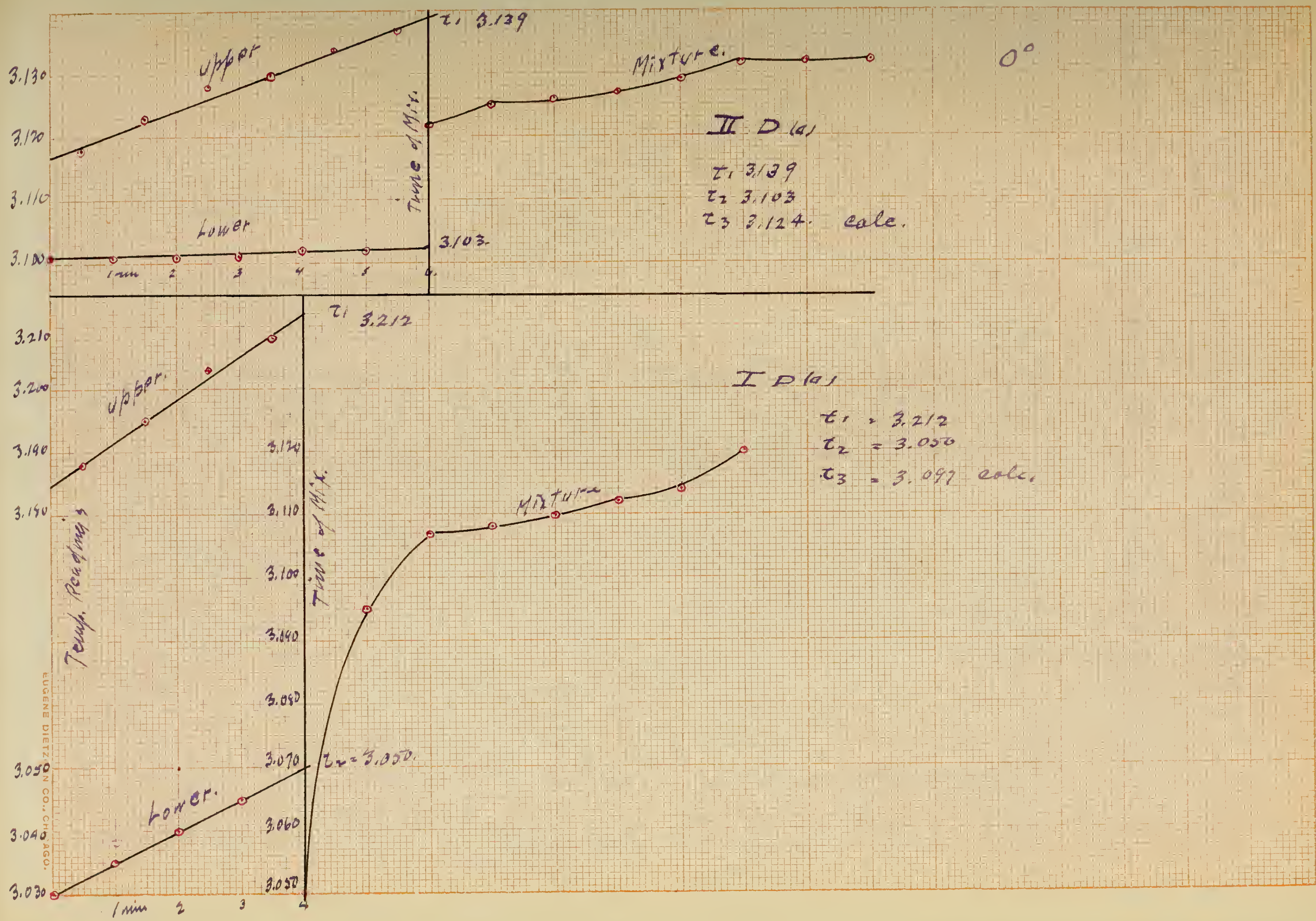
Value for K used
= 52 cal.


Curve for Specific Heat
of Sugar Solutions.
values taken from
Landolt and Bornstein.
Specific Heat.
1.00
.90
.80
.70
Mols of sugar per mole of Water.
.002
.004
.010
.015
.018
EUGENE DIETZGEN CO., CHICAGO.

0°   Table I O

500 g water }
271 g Sugar } Below Diluted with 200 g water.

(a)		(b)	
Upper Flask.	Lower Flask.	Upper Flask.	Lower Dewar.
3.188°C	3.030°C	3.118°C	3.100°C
3.195°C	3.035°C	3.123° "	3.101°C
3.203°C	3.040°C	3.128° "	3.101°C
3.208°C	3.045°C	3.130° "	3.101° "
		3.134° "	3.102° "
		3.136° "	3.102° "
Mixture.	3.050°C		
	3.095° "	Mixture.	3.122° "
	3.107°		3.125°
	3.108°		3.126°
	3.110		3.127°
	3.112		3.129°
Stopped stirring.	3.115		3.130°
to see influence.	3.120		3.132°
	3.120		3.132°
	3.121		3.132°
	3.121		



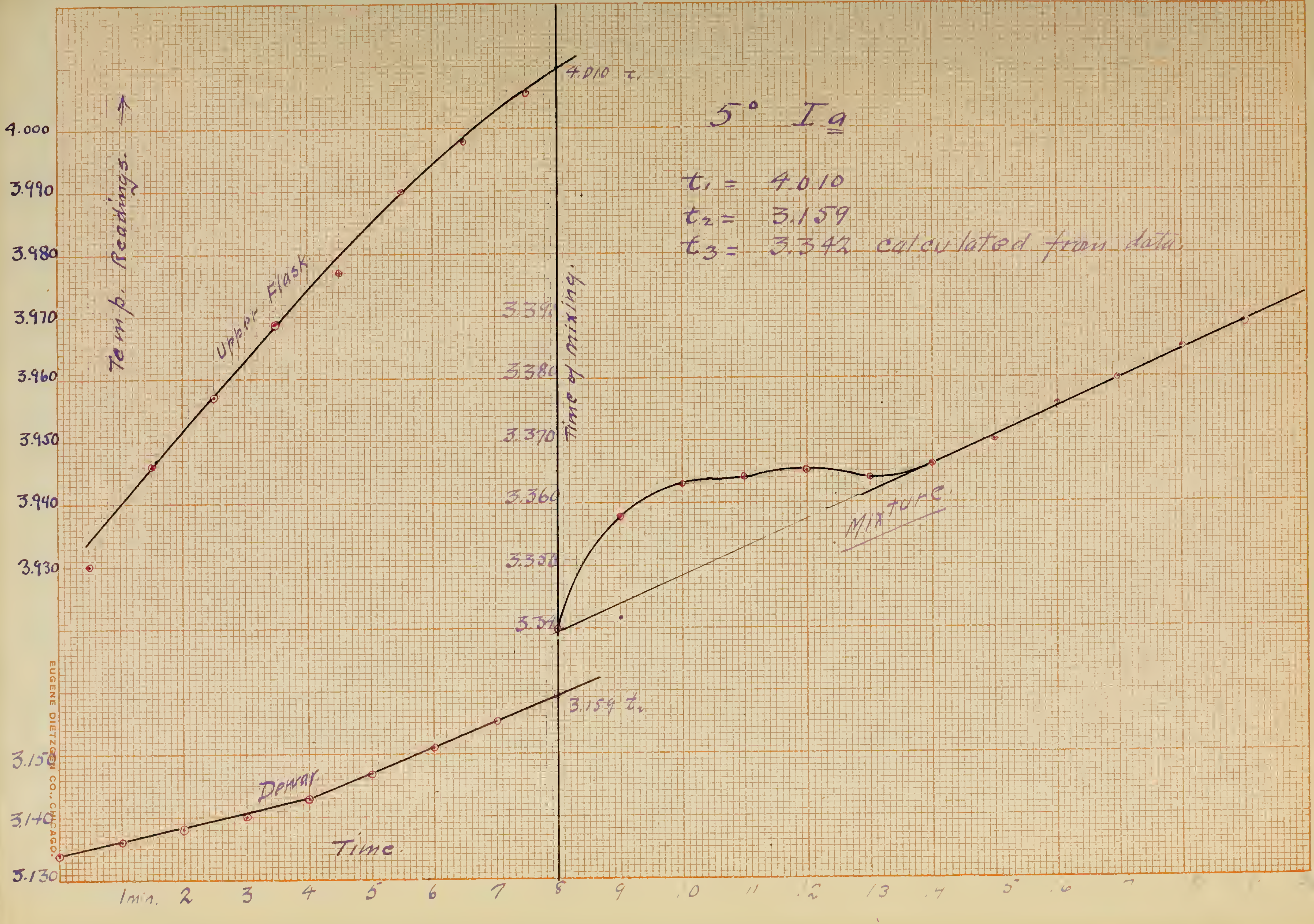
0°
upper
Lower
Mixture.
Time of Mix.
τ1 3.139
3.103.
II D (a)
τ1 3.139
τ2 3.103
τ3 3.124. calc.
τ1 3.212
upper.
Lower.
Mixture
Time of Mix.
τ2 = 3.050.
I D (a)
τ1 = 3.212
τ2 = 3.050
τ3 = 3.097 calc.
Temp. Readings
1 min
EUGENE DIETZGEN CO., CHICAGO.

5° Table I A.

500g. Water }
171 g. Sugar } Diluted With 200 g of Water

Temperature Readings taken at minute intervals.

a.		b.	
Upper Flask	Lower Dewar	Upper Flask	Lower Dewar.
3.930° C	3.134° C	3.992° C.	3.260° C
3.946° "	3.136° "	3.998° "	3.265° "
3.957° "	3.138° "	4.008° "	3.275° "
3.959° "	3.140° "	4.018° "	3.280° "
3.977° "	3.143° "	4.029° "	3.284° "
3.990° "	3.147° "	4.041° "	3.288° "
3.998° "	3.151° "	4.050° "	3.291° "
4.006° "	3.155° "		
			3.415° "
Mixture	3.340° "	Mixture.	3.431° "
	3.358° "		3.460° "
	3.363° "		3.460° "
	3.364° "		3.461° "
	3.365° "		3.464° "
	3.364° "		3.470° "
	3.366° "		3.474° "
	3.370° "		3.479° "
	3.376° "		3.483° "
	3.380° "		3.488° "
	3.385° "		3.492° "
	3.389° "		


5° I a
t₁ = 4.010
t₂ = 3.159
t₃ = 3.342 calculated from data
Temp. Readings.
Upper Flask
Time of mixing.
4.010 t₁
3.159 t₂
Mixture
Dewar.
Time.
1 min.
4.000
3.990
3.980
3.970
3.960
3.950
3.940
3.930
3.150
3.140
3.130
3.370
3.360
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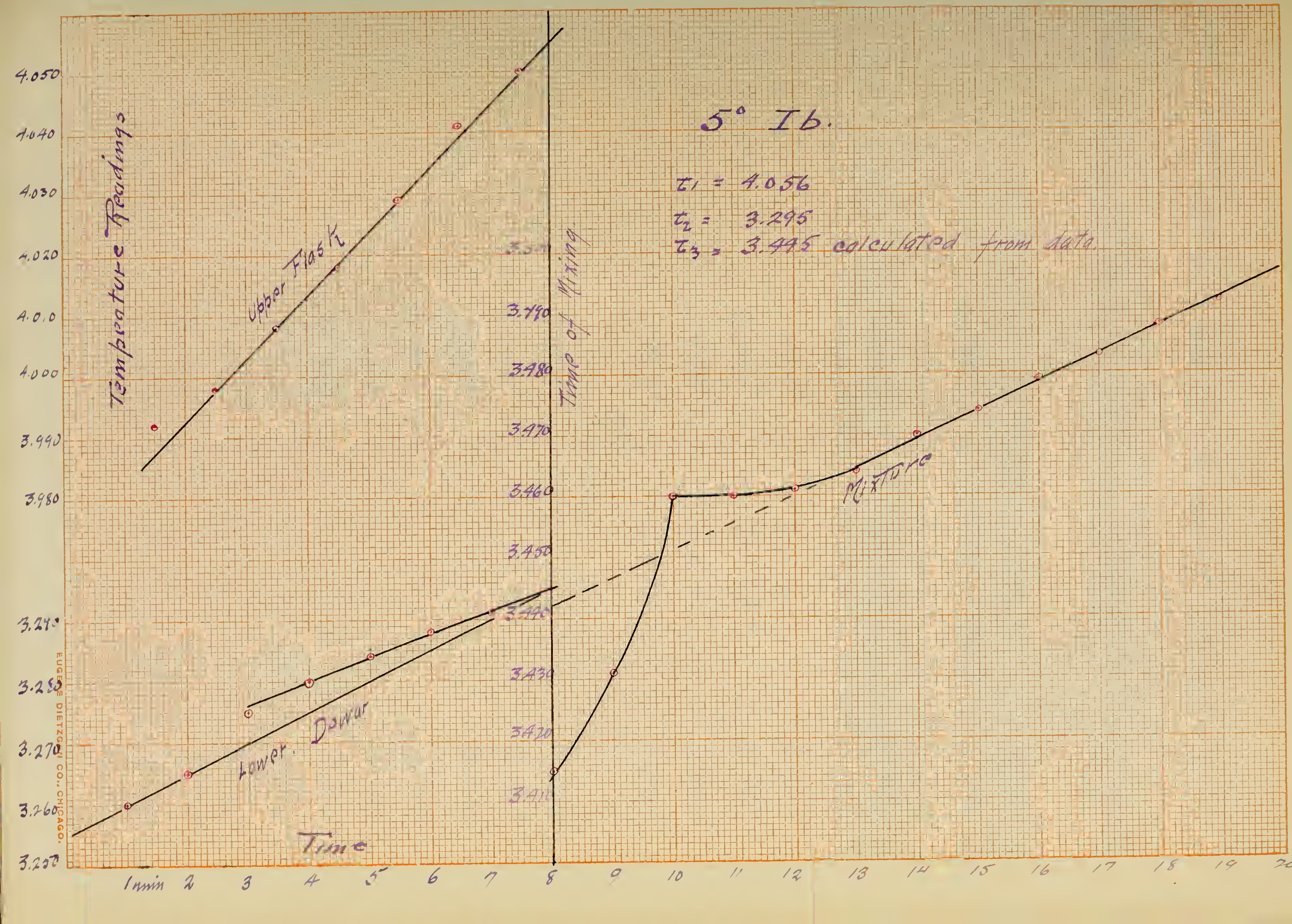


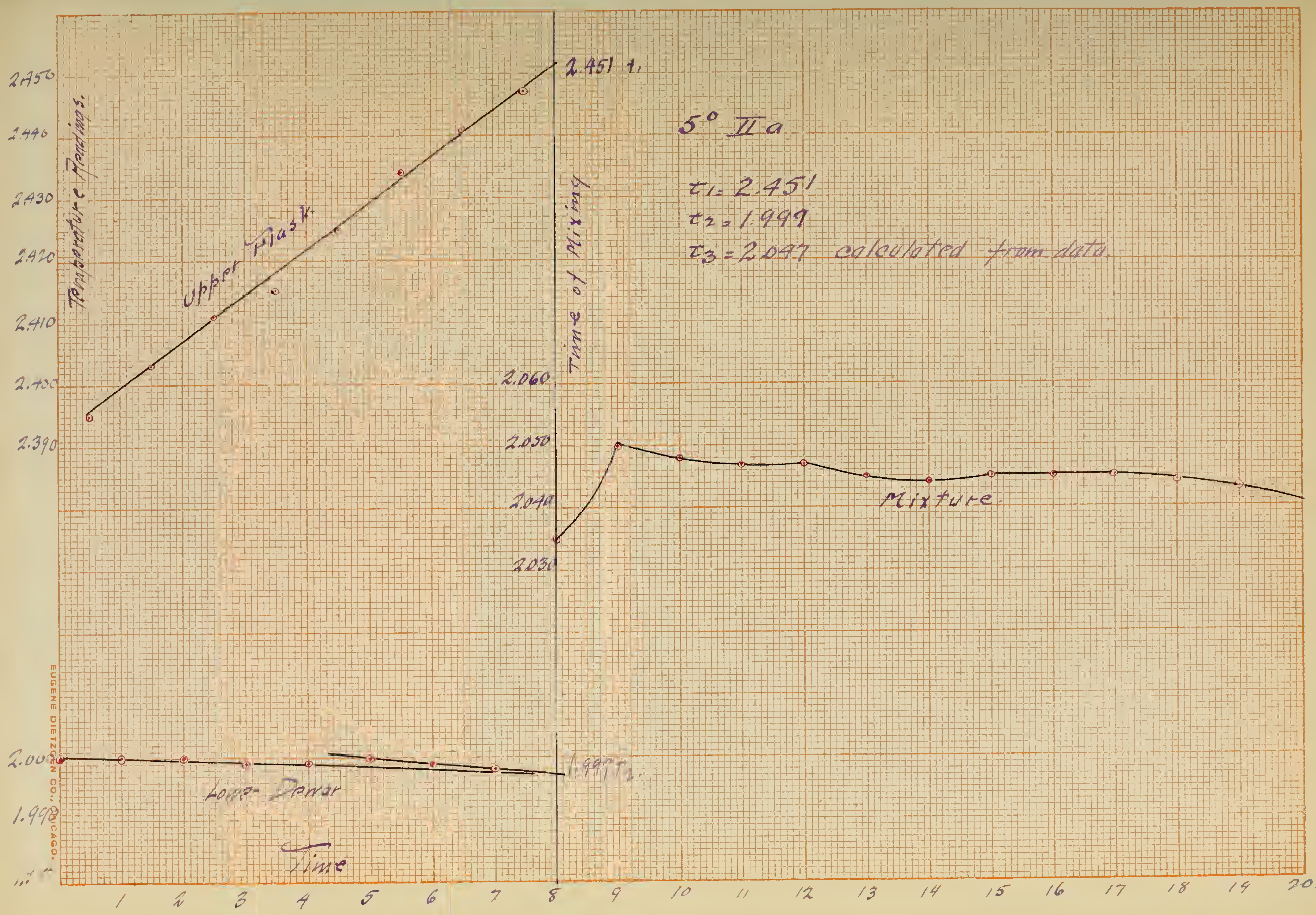
5° Ib.
t_1 = 4.056
t_2 = 3.295
t_3 = 3.495 calculated from data.
Temperature Readings
Upper Flask t_1
Lower Dewar
Mixture
Time of Mixing
Time
4.050
4.040
4.030
4.020
4.0.0
4.000
3.990
3.980
3.290
3.280
3.270
3.260
3.250
3.490
3.480
3.470
3.460
3.450
3.440
3.430
3.420
3.410
1 min
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
EUGENE DIETZGEN CO., CHICAGO.

5° Table II A

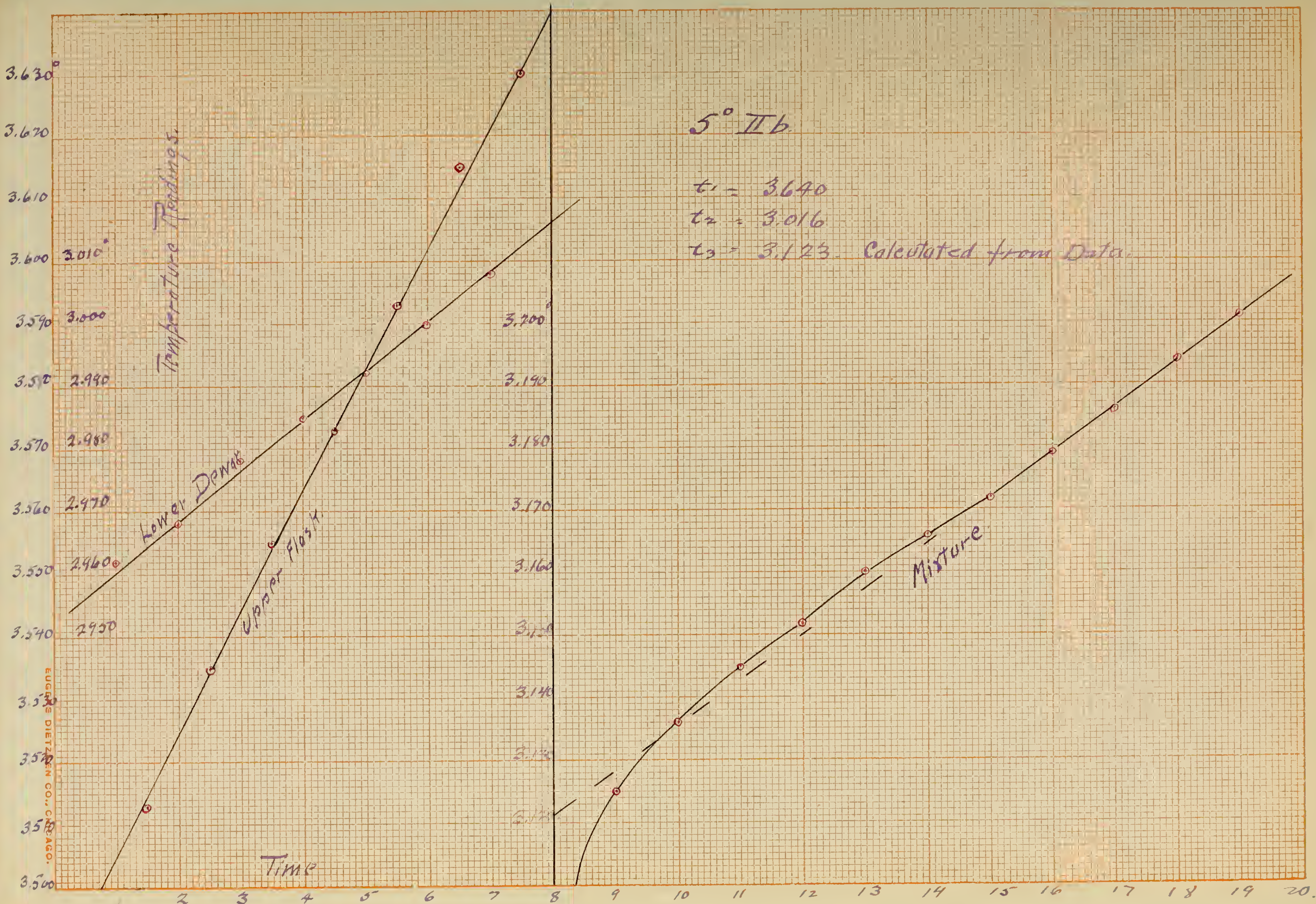
550 g Water } Diluted with 150 g Water
188.1 g Sugar }

Temperature Readings taken at minute Intervals.

a.		b.	
Upper Flask	Lower Dewar	Upper Flask	Lower Dewar
2.395° C	2.000° C	3.498° C	2.942° C
2.403° "	2.000° "	3.513° "	2.962° "
2.411° "	2.000° "	3.535° "	2.968° "
2.415° "	1.999° "	3.555° "	2.978° "
2.425° "	1.999° "	3.573° "	2.985° "
2.434° "	2.000° "	3.593° "	2.992° "
2.441° "	1.999° "	3.615° "	3.000° "
2.447° "	1.998° "	3.630° "	3.008° "
Mixture	2.035° "	Mixture	3.070° "
	2.050° "		3.125° "
	2.048° "		3.136° "
	2.047° "		3.145° "
	2.047° "		3.152° "
	2.045° "		3.160° "
2.043° C	2.044° "		3.166° "
2.042° "	2.045° "		3.172° "
2.042° "	2.045° "		3.179° "
2.042° "	2.045° "		3.186° "
	2.044° "		3.194° "
	2.043° "		3.201° "



5° IIa
t1 = 2.451
t2 = 1.999
t3 = 2.047 calculated from data.
Temperature Readings.
Upper Flask.
Time of Mixing
2.451 t1
Mixture.
Lower Dewar
1.999 t2
Time
2.450
2.440
2.430
2.420
2.410
2.400
2.390
2.060
2.050
2.040
2.030
2.000
1.998
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20.
EUGENE DIETZGEN CO., CHICAGO.


5° IIb
t_1 = 3.640
t_2 = 3.016
t_3 = 3.123 Calculated from Data.
Temperature Readings.
Lower Dewar
Upper Flask
Mixture
Time
EUGENE DIETZGEN CO., CHICAGO.

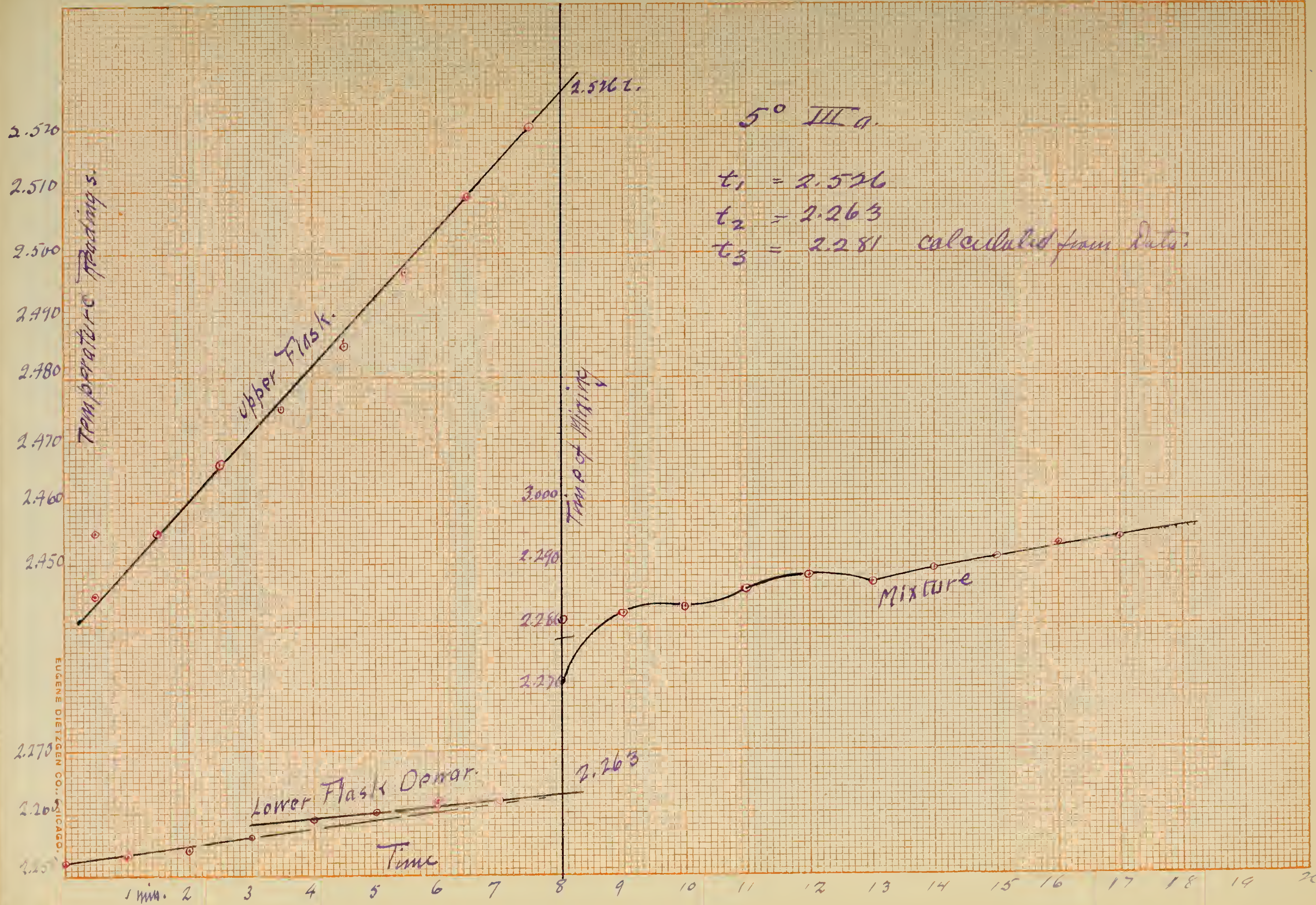
5° Table III A.

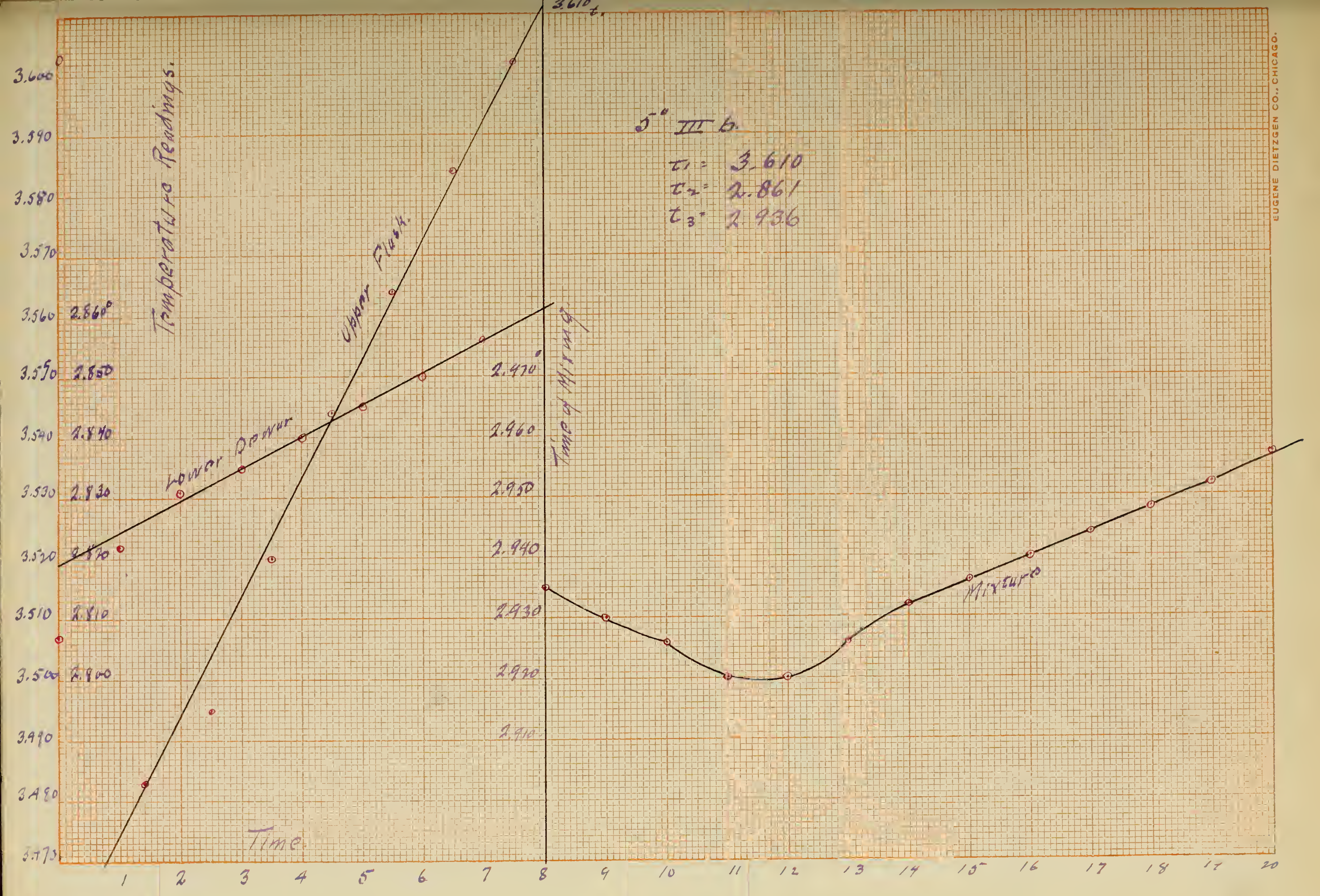
600 g. Water } Diluted with 100 g Water.
205.2 g Sugar }

Temperature Readings taken at Minute Intervals.

a. Upper Flask.	a. Dewar. Lower Flask.	b. Upper Flask.	b. Dewar Lower Flask.
2.445° C	2.252 °C	3.465° C	2.807° C
2.455° "	2.253° "	3.483° "	2.823° "
2.466° "	2.254° "	3.495° "	2.831° "
2.475° "	2.256° "	3.520° "	2.835° "
2.486° "	2.259° "	3.544° "	2.840° "
2.497° "	2.260° "	3.564° "	2.845° "
2.509° "	2.261° "	3.584° "	2.851° "
2.520° "	2.262° "	3.602° "	2.856° "

a. Mixture		b. Mixture	
	2.272° "	½ Min. Readings.	2.935° "
	2.282° "		2.930° "
	2.283° "		2.926° "
	2.284° "		2.920° "
	2.286° "		2.920° "
	2.288° "		2.926° "
	2.287° "	Min. Readings.	2.932° "
	2.289° "	" " "	2.936° "
	2.291° "	" " "	2.940° "
	2.293° "	" " "	2.944° "
	2.294° "	" " "	2.948° "
		" " "	2.952° "


5° III a.
t_1 = 2.526
t_2 = 2.263
t_3 = 2.281 calculated from Data.
Temperature Readings.
Upper Flask.
2.526.
Time of Mixing
Mixture
Lower Flask Dewar.
2.263
Time
1 min. 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
2.520
2.510
2.500
2.490
2.480
2.470
2.460
2.450
3.000
2.290
2.280
2.270
2.260
EUGENE DIETZGEN CO., CHICAGO.


Temperature Readings.
5° III b.
t1 = 3.610
t2 = 2.861
t3 = 2.936
Upper Flask.
Lower Power
Time of Mixing
Mixture
Time
3.610 t.
3.600
3.590
3.580
3.570
3.560
3.550
3.540
3.530
3.520
3.510
3.500
3.490
3.480
2.860°
2.850
2.840
2.830
2.820
2.810
2.800
2.970°
2.960
2.950
2.940
2.930
2.920
2.910
1
2
3
4
5
6
7
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10
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12
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14
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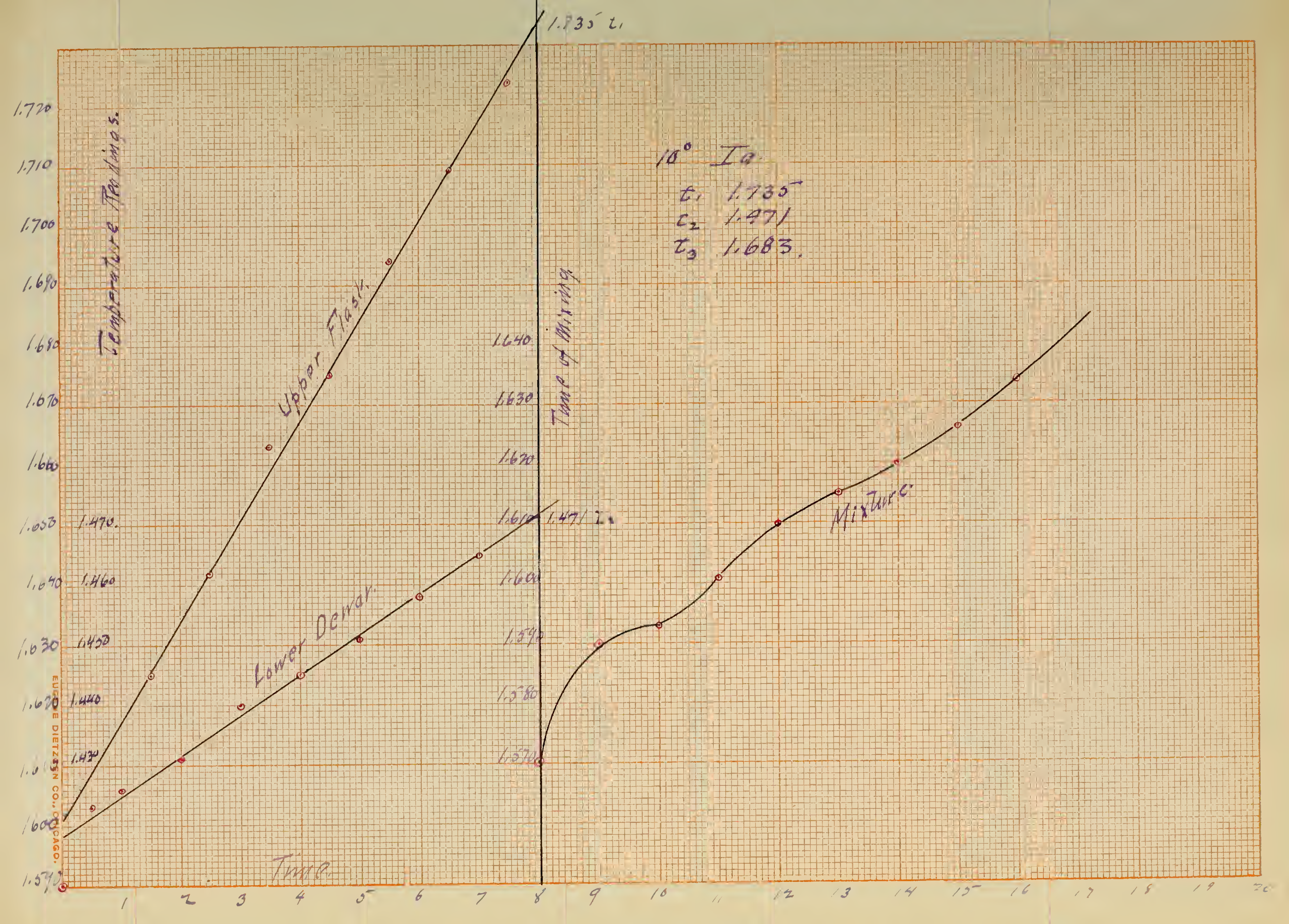
17
18
19
20
EUGENE DIETZGEN CO., CHICAGO.

10° Table I B.

500 g. Water }
171 g Sugar } Diluted with 200 g Water.

Temperatur Readings taken at Minute Intervals.

a.		b.	
Upper Flask.	Lower Dewar	Upper Flask.	Lower Dewar
1.604° C	1.426° C	1.474° C	1.419° C
1.625° "	1.431° "	1.496° "	1.428° "
1.642° "	1.440° "	1.522° "	1.435° "
1.663° "	1.445° "	1.541° "	1.443° "
1.675° "	1.451° "	1.559° "	1.450° "
1.694° "	1.458° "	1.576° "	1.456° "
1.709° "	1.465° "	1.594° "	1.464° "
1.724° "	1.470° "	1.613° "	1.471° "
			1.477° "
Mixture		Mixture	
	1.570° "		1.575° "
	1.591° "		1.585° "
	1.593° "		1.585° "
	1.601° "		1.589° "
	1.610° "		1.592° "
	1.615° "		1.600° "
	1.620° "		1.608° "
	1.626° "		1.614° "
	1.634° "		1.621° "
			1.628° "
			1.635° "
			1.642° "



Temperature Readings.
Upper Flask.
Lower Dewar.
Mixture
Time of Mixing
Time
1.735 t_1
1.471 t_2
10° Ia
t_1 1.735
t_2 1.471
t_3 1.683.
1.720
1.710
1.700
1.690
1.680
1.670
1.660
1.650
1.640
1.630
1.620
1.600
1.590
1.470.
1.460
1.450
1.440
1.430
1.640
1.630
1.620
1.610
1.600
1.590
1.580
1.570
1
2
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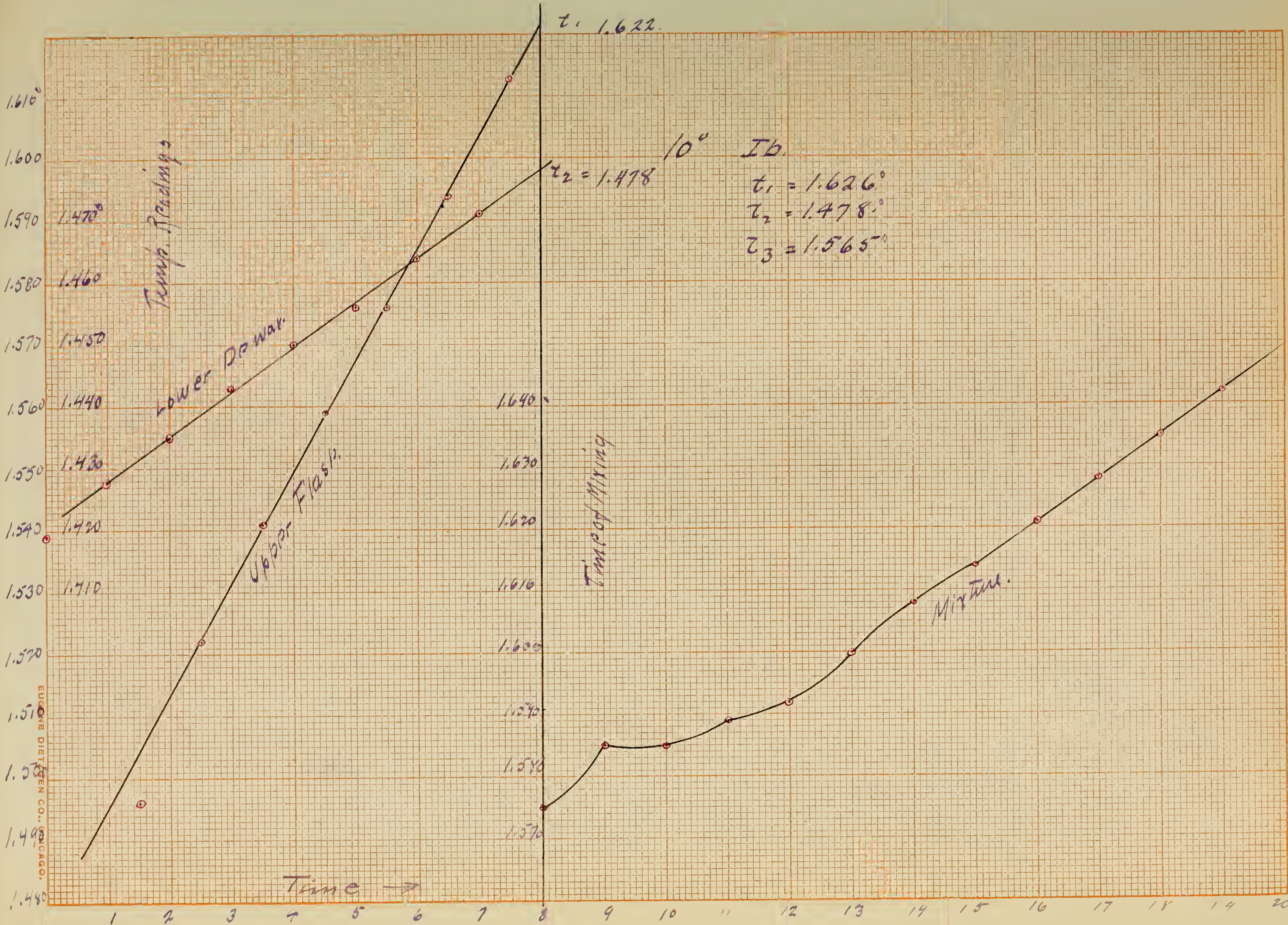
EUGENE DIETZGEN CO., CHICAGO.



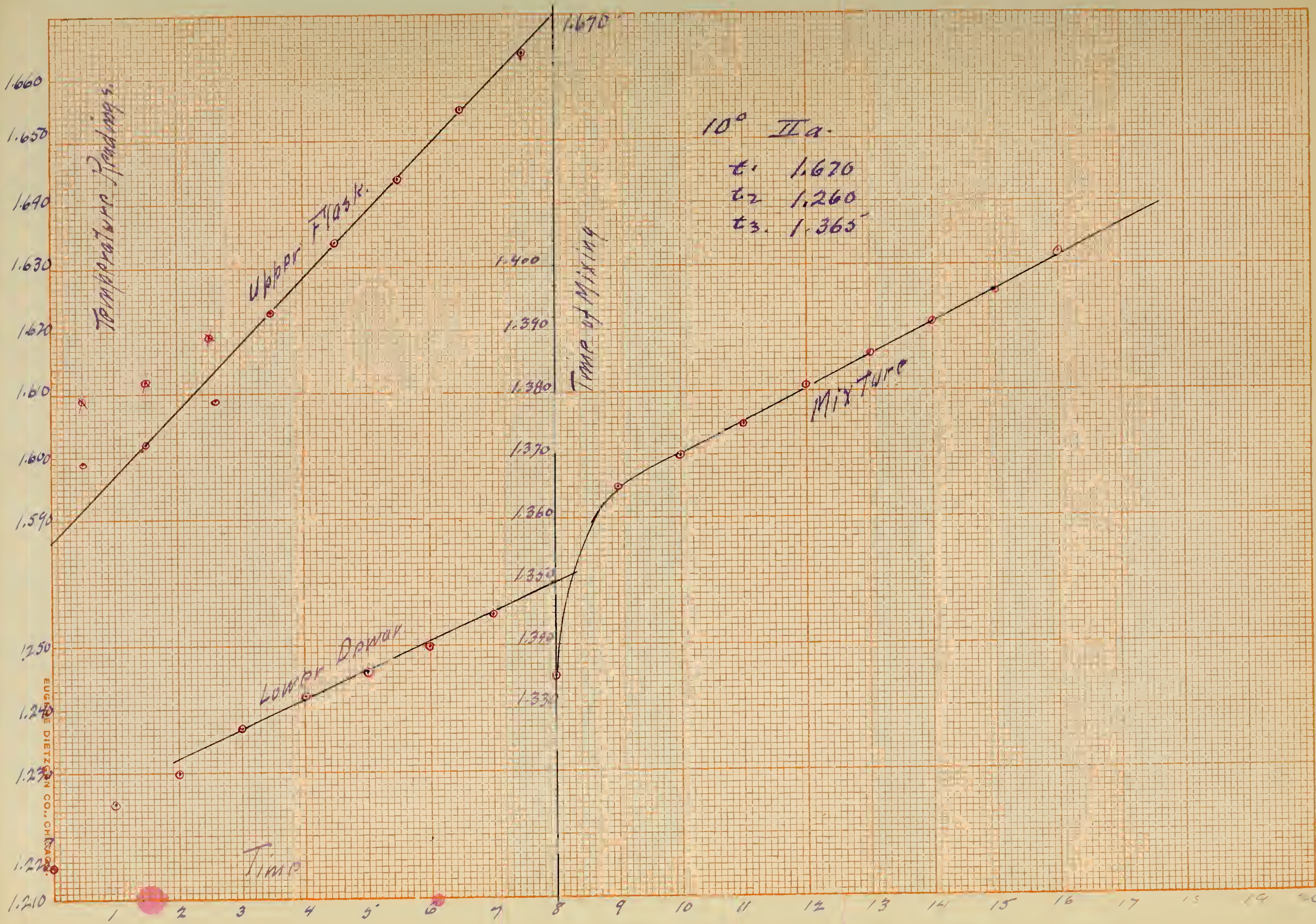
10° Ib.
$t_1 = 1.626°$
$t_2 = 1.478°$
$t_3 = 1.565°$
t_1 1.622.
$t_2 = 1.478$
Temp. Readings
Lower Dewar.
Upper Flask.
Time of Mixing
Mixture.
Time →
EUGENE DIETZGEN CO., CHICAGO.

10° Table II B

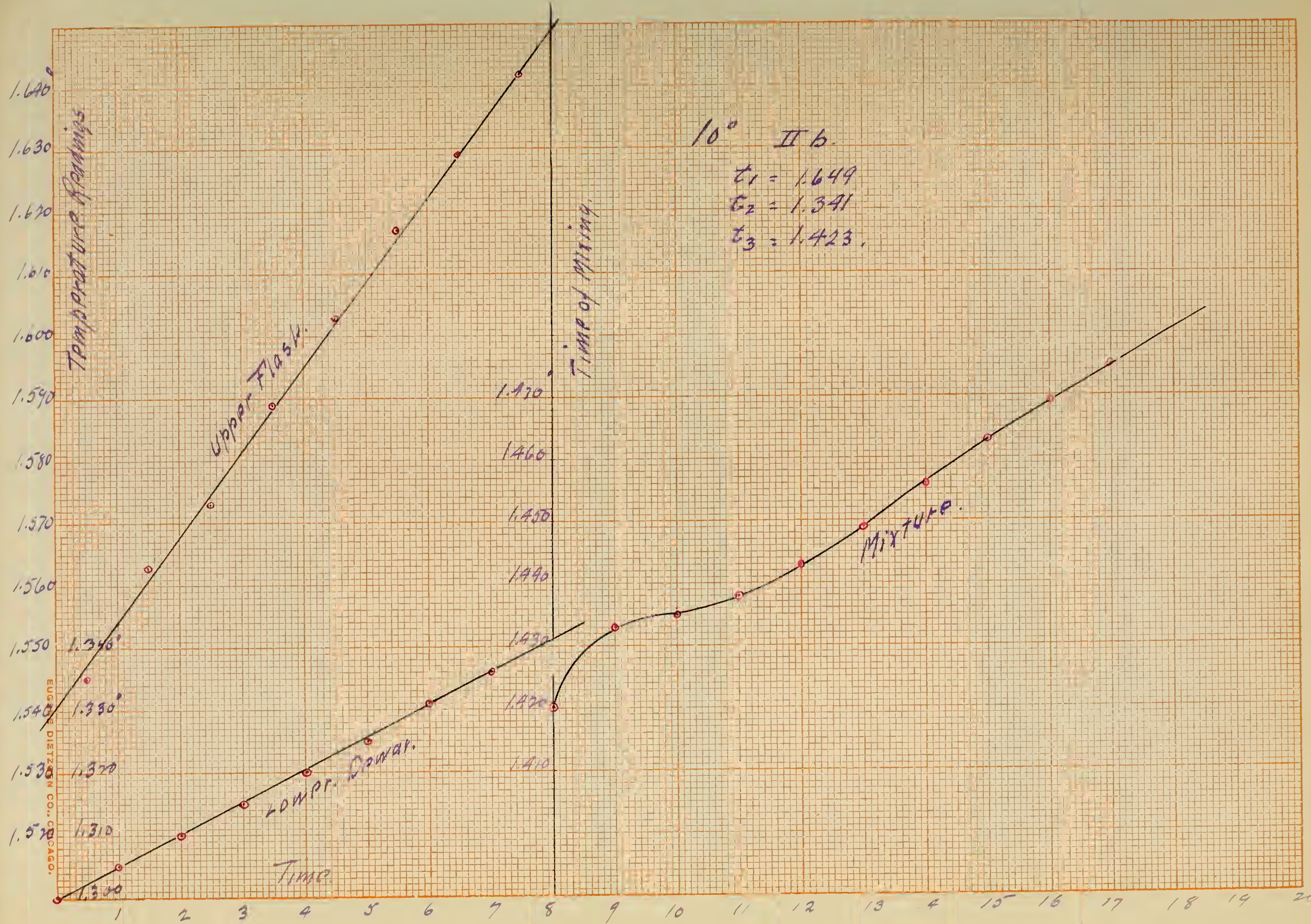
550 Water
188.1 Sugar } Diluted with 150g Water.

Temperature Readings taken at Minute Intervals.

a.		b.	
Upper Flask.	Lower. Dewar	Upper Flask.	Lower. Dewar.
1.599° C	1.215° C	1.545° C	1.300° C
1.602° "	1.225° "	1.563° "	1.305° "
1.609° "	1.230° "	1.574° "	1.310° "
1.623° "	1.237° "	1.589° "	1.315° "
1.634° "	1.242° "	1.603° "	1.320° "
1.644° "	1.245° "	1.617° "	1.325° "
1.655° "	1.247° "	1.629° "	1.331° "
1.664° "	1.250° "	1.642° "	1.338° "
	1.255° "		
Mixture	1.335° "	Mixture	1.420° C
	1.366° "		1.433° "
	1.370° "		1.435° "
	1.375° "		1.438° "
	1.381° "		1.443° "
	1.386° "		1.449° "
	1.391° "		1.456° "
	1.396° "		1.463° "
	1.402° "		1.469° "
			1.475° "



Temperature Readings.
Upper Flask.
Lower Dewar.
Mixture
Time of Mixing
Time
10° IIa.
t_1 1.670
t_2 1.260
t_3 1.365
1.670
1.660
1.650
1.640
1.630
1.620
1.610
1.600
1.590
1.250
1.240
1.230
1.220
1.210
1.400
1.390
1.380
1.370
1.360
1.350
1.340
1.330
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
EUGENE DIETZGEN CO., CHICAGO.


10° II b.
t_1 = 1.649
t_2 = 1.341
t_3 = 1.423.
Temperature Readings
Upper Flask.
Lower Dewar.
Mixture.
Time of Mixing.
Time
1.640°
1.630
1.620
1.610
1.600
1.590
1.580
1.570
1.560
1.550
1.540
1.530
1.520
1.340°
1.330°
1.320
1.310
1.300
1.470
1.460
1.450
1.440
1.430
1.420
1.410
1
2
3
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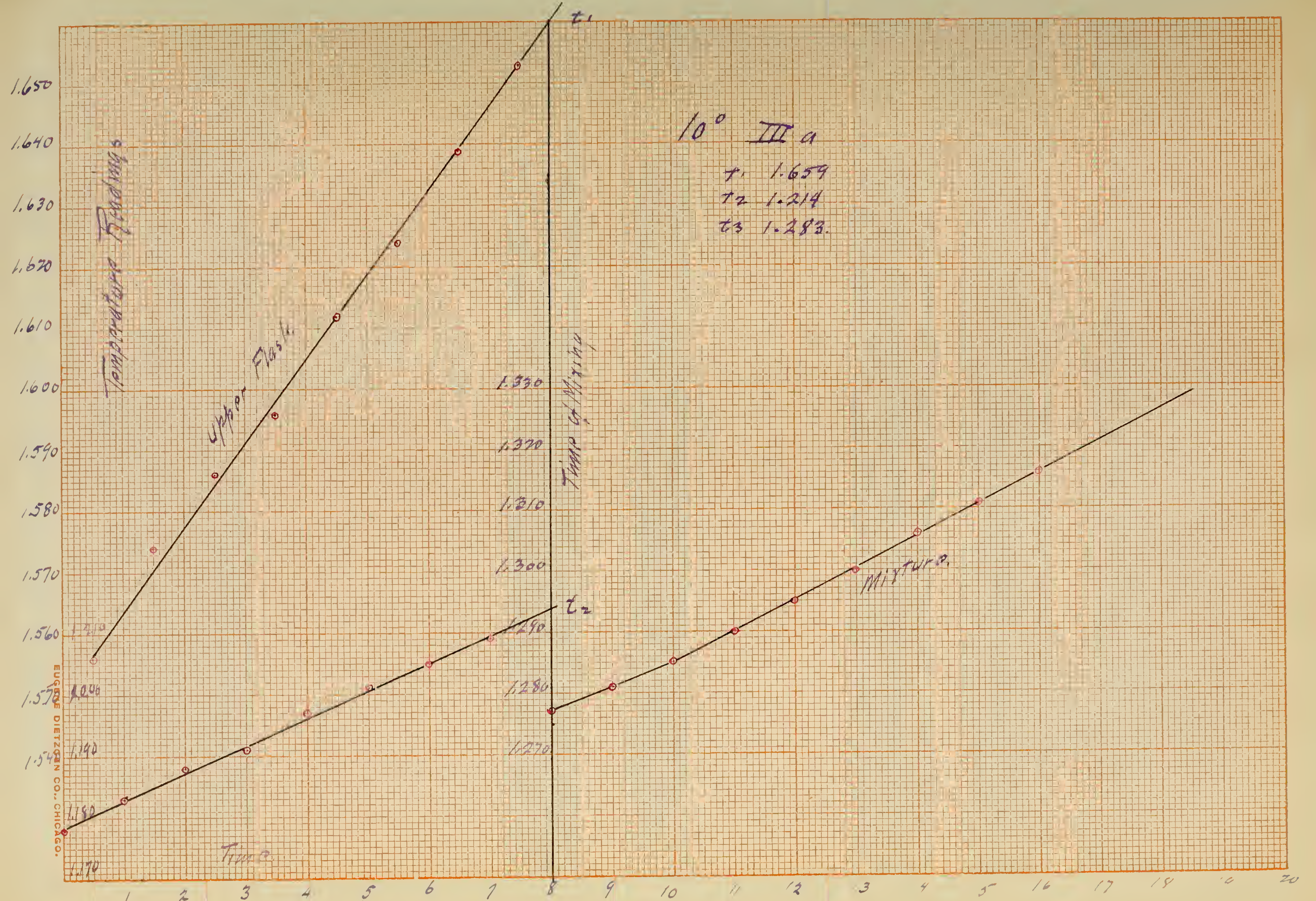
EUGENE DIETZGEN CO., CHICAGO.

10°. Table III. E.

600g Water }
200.2g Sugar } Diluted with 100g Water.

Temperature Readings Taken at Minute Intervals.

a. Upper Flask.	a. Lower Dewar	b. Upper Flask.	b. Lower Dewar
1.556° C	1.178° C	1.654° C	1.250° C
1.574° "	1.183° "	1.664° "	1.256° "
1.586° "	1.188° "	1.674° "	1.262° "
1.596° "	1.191° "	1.683° "	1.268° "
1.612° "	1.197° "	1.690° "	1.272° "
1.624° "	1.201° "	1.698° "	1.277° "
1.639° "	1.205° "	1.705° "	1.281° "
1.653° "	1.209° "	1.711° "	1.285° "
Mixture	1.287° "	Mixture	1.357° "
	1.289° "		1.366° "
	1.291° "		1.366° "
	1.295° "		1.366° "
	1.300° "		1.370° "
	1.305° "		1.372° "
	1.310° "		1.375° "
	1.316° "		1.378° "
	1.321° "		1.381° "
	1.326° "		1.384° "


10° III a
t_1 1.659
t_2 1.214
t_3 1.283.
Temperature Readings
Upper Flask
Mixture.
Time of Mixing
Time
t_1
t_2
1.650
1.640
1.630
1.620
1.610
1.600
1.590
1.580
1.570
1.560
1.330
1.320
1.310
1.300
1.290
1.280
1.270
1.180
1.170
1
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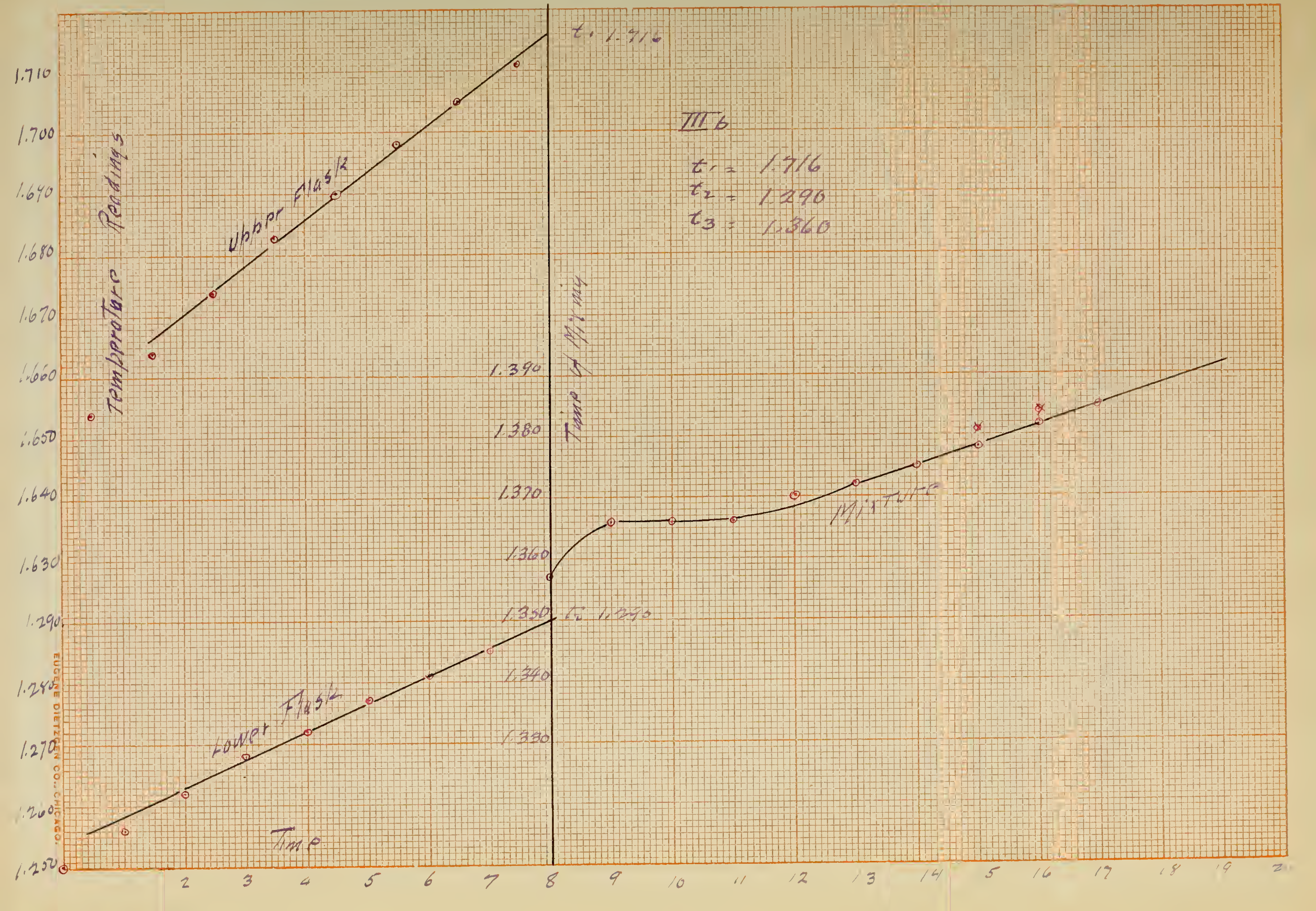
EUGENE DIETZGEN CO., CHICAGO.



III b
$t_1 = 1.716$
$t_2 = 1.290$
$t_3 = 1.360$
t_1 1.716
t_2 1.290
Temperature Readings
Upper Flask
Lower Flask
Mixture
Time of Mixing
Time
1.710
1.700
1.690
1.680
1.670
1.660
1.650
1.640
1.630
1.290
1.280
1.270
1.260
1.250
1.390
1.380
1.370
1.360
1.350
1.340
1.330
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EUGENE DIETZGEN CO., CHICAGO.

15° Table I C.

500 g. Water } Diluted with 200 g water.
171 g Sugar }

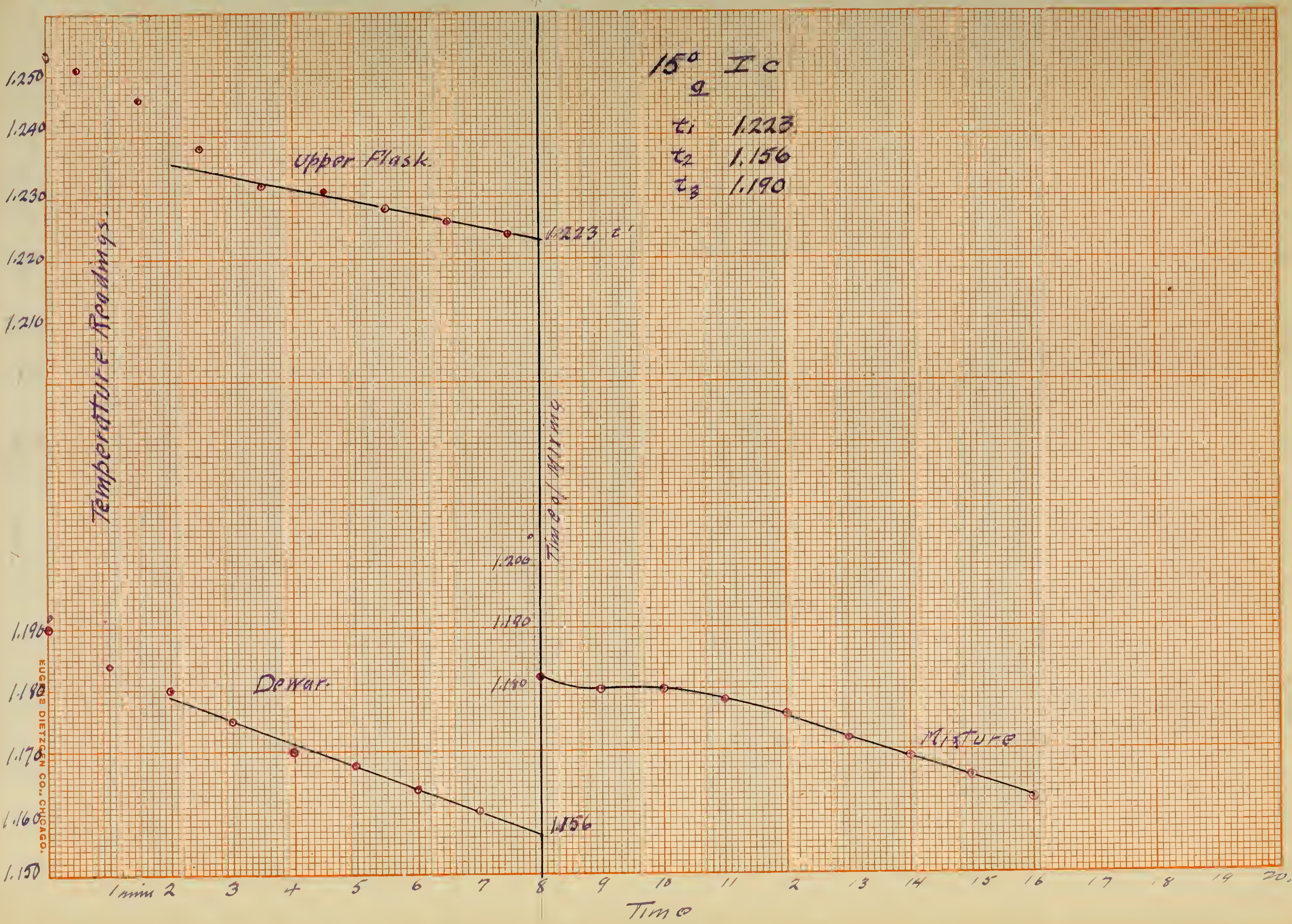
Temperature Readings taken at minute Intervals.

a.

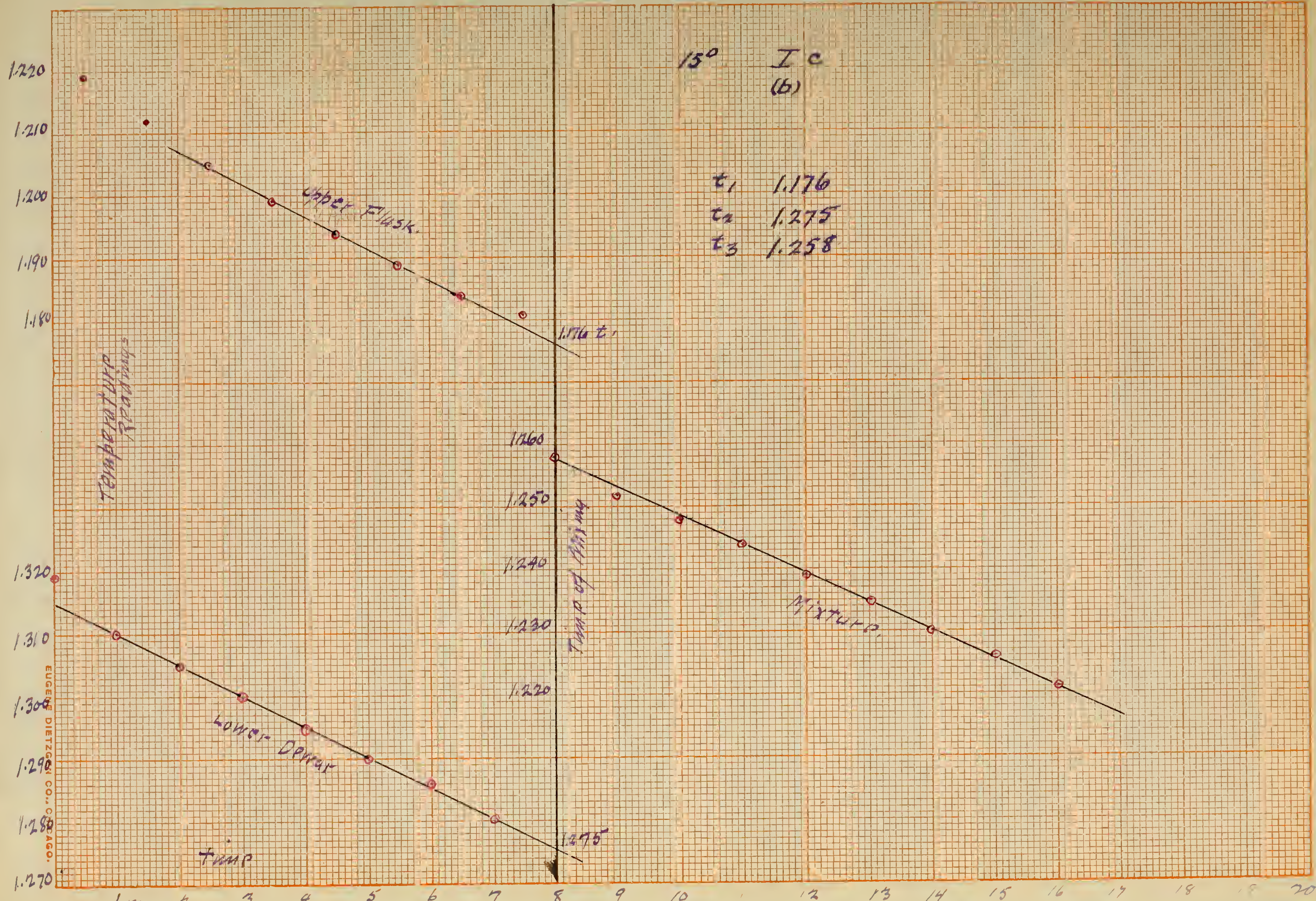
Upper Flask	Lower Dewar
1.251° C	1.190° C
1.246° "	1.184° "
1.238° "	1.180° "
1.232° "	1.175° "
1.230° "	
1.228° "	1.170° "
1.226° "	1.168° "
1.224° "	1.164° "
	1.160° "
Mixture	1.182° "
	1.180° "
	1.180° "
	1.178° "
	1.176° "
	1.172° "
	1.169° "
	1.166° "
	1.162° "

b.

Upper Flask	Lower Dewar
1.219° C	1.319° C
1.212° "	1.310° "
1.205° "	1.305° "
1.199° "	1.300° "
1.194° "	1.295° "
1.189° "	1.290° "
1.184° "	1.286° "
1.181° "	1.280° "
	1.258° "
Mixture	1.252° "
	1.248° "
	1.244° "
	1.239° "
	1.235° "
	1.230° "
	1.226° "
	1.221° "



15° I c
9
t_1 1.223
t_2 1.156
t_3 1.190
Upper Flask
1.223 t'
Time of Mixing
Dewar
1.156
Mixture
Temperature Readings
1.250
1.240
1.230
1.220
1.210
1.200
1.190
1.180
1.170
1.160
1.150
1 min 2
3
4
5
6
7
8
9
10
11
2
13
14
15
16
17
18
19
20.
Time
EUGENE DIETZGEN CO., CHICAGO.


15°
I c
(b)
t_1 1.176
t_2 1.275
t_3 1.258
Upper Flask.
1.176 t_1
Temperature Readings
Time of Mixing
Mixture.
Lower Dewar
1.275
Time
1.220
1.210
1.200
1.190
1.180
1.260
1.250
1.240
1.230
1.220
1.320
1.310
1.300
1.290
1.280
1.270
1 min
2
3
4
5
6
7
8
9
10
12
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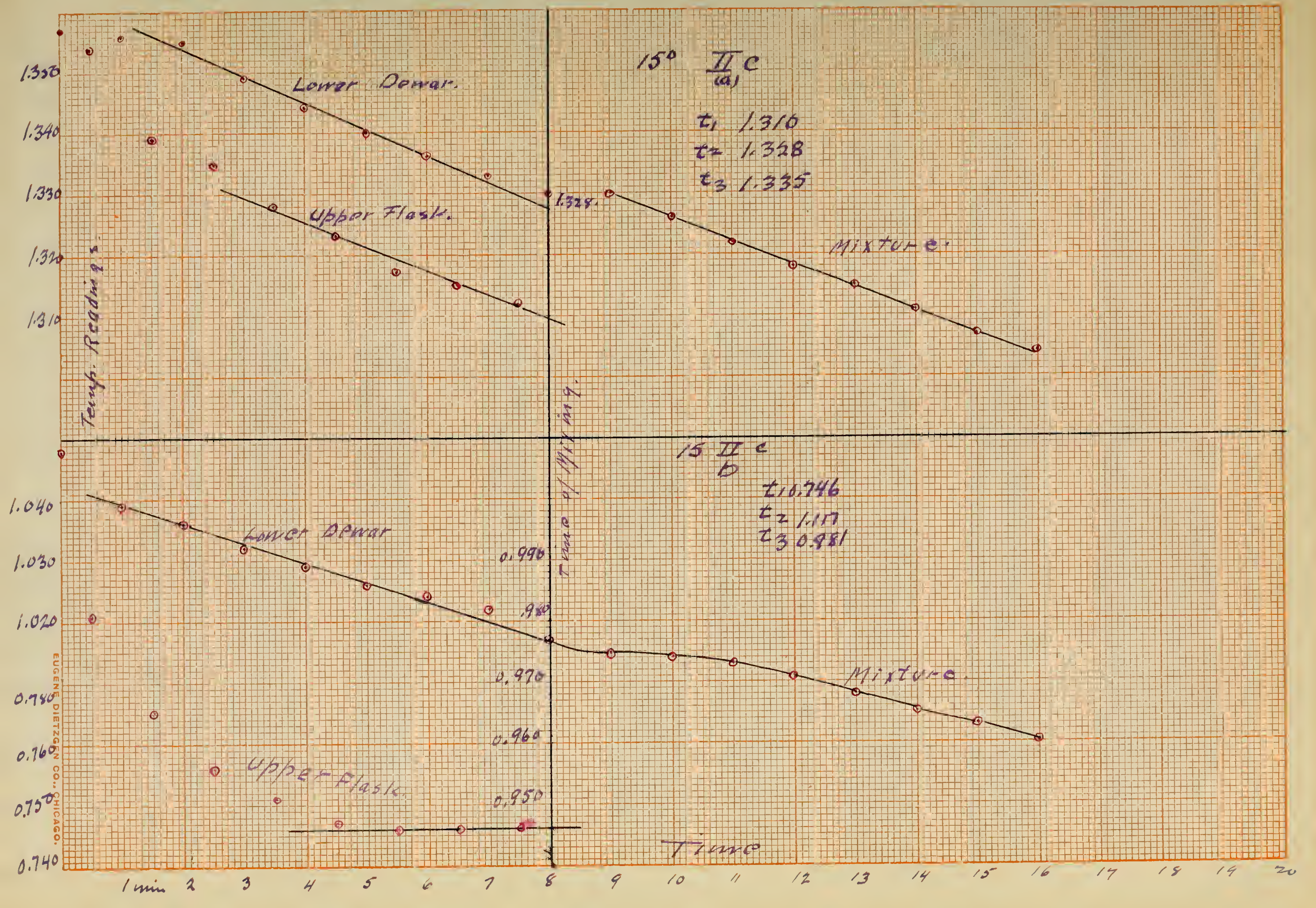
EUGENE DIETZGEN CO., CHICAGO.

15° Table II C.

550g Water
188.1g. Sugar } Diluted with 150g Water

Temperature readings taken at minute Intervals.

a. Upper Flask	a. Lower Dewar	b. Upper Flask	b. Lower Dewar
1.354° C	1.357° C	0.781° C	1.048° C
1.339° "	1.356° "	0.765° "	1.039° "
1.335° "	1.355° "	0.756° "	1.036° "
			1.032°
1.328° "	1.349° "	0.751° "	1.029° "
1.323° "	1.344° "	0.747° "	1.026° "
1.317° "	1.340° "	0.746° "	1.024° "
1.316° "	1.336° "	0.746° "	1.022° "
1.312° "	1.333° "	0.746° "	
Mixture		Mixture	0.980° C
	1.330° "		0.975° "
	1.330° "		0.974° "
	1.326° "		0.973° "
	1.322° "		0.971° "
	1.318° "		0.968° "
	1.315° "		0.965° "
	1.311° "		0.963° "
	1.307° "		0.960° "
	1.304° "		0.957° "
	1.301° "		



15° $\frac{II}{(a)}$ C
t_1 1.310
t_2 1.328
t_3 1.335
Lower Dewar.
Upper Flask.
Mixture.
1.328.
Temp. Readings
Time of Mixing.
15 $\frac{II}{b}$ c
t_1 0.746
t_2 1.117
t_3 0.981
Lower Dewar
Upper Flask.
Mixture.
Time
1.350
1.340
1.330
1.320
1.310
1.040
1.030
1.020
0.780
0.760
0.750
0.740
0.990
.980
0.970
0.960
0.950
1 min 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
EUGENE DIETZGEN CO., CHICAGO.

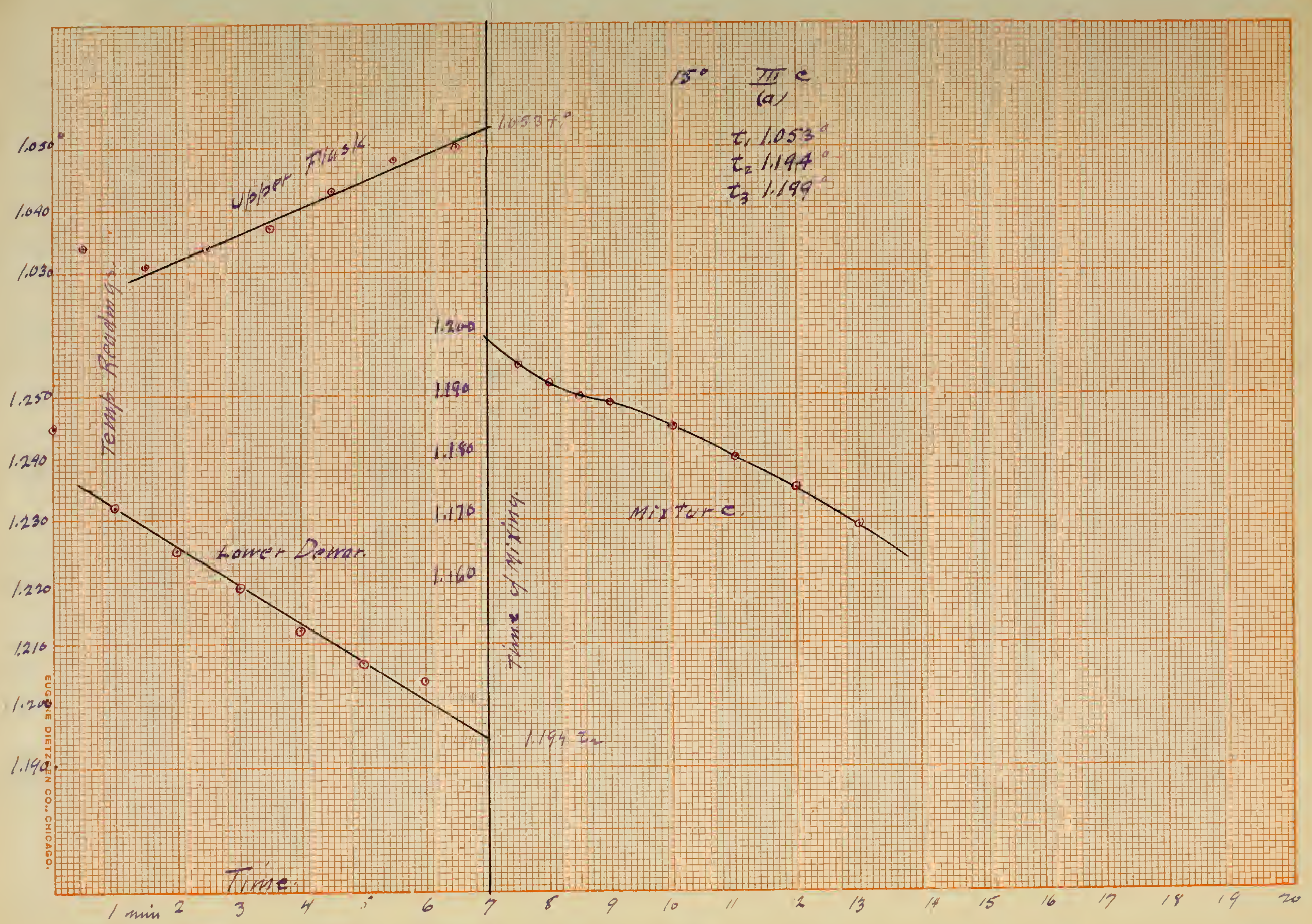
15° Table III C.

600 g Water
205.2 g Sugar } Diluted with 100 g of water

Temperature Readings Taken at Minute Intervals.

a.		b.	
Upper Flask.	Lower Dewar	Upper Flask	Lower Dewar
1.034 °C	1.245 °C	1.277 °C	0.975 °C
1.031° "	1.232° "	1.267° "	0.970° "
1.034° "	1.225° "	1.257° "	0.965° "
1.037° "	1.219° "	1.247° "	0.960° "
1.043° "	1.212° "		
1.048° "	1.207° "		
1.050° "	1.204° "		

a. Mixture		b. Mixture	
½ min. readings.	1.199° "	½ min readings.	0.997
	1.995° "		0.996
	1.992° "		0.990
	1.990° "	1 min readings	0.990
1 min readings.	1.989° "	" "	0.987
" "	1.985° "	" "	0.985
" "	1.980° "	" "	0.983
" "	1.975° "	" "	0.983
" "	1.965° "	" "	0.979
		" "	0.975


15° III c (a)
t_1 1.053°
t_2 1.194°
t_3 1.199°
1.053 t_1°
Upper Flask.
Temp. Readings.
Lower Dewar.
Time of Mixing.
Mixture c.
1.194 t_2
Time.
1 min 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20.
1.050° 1.040 1.030 1.250 1.240 1.230 1.220 1.210 1.200 1.190.
1.200 1.190 1.180 1.170 1.160
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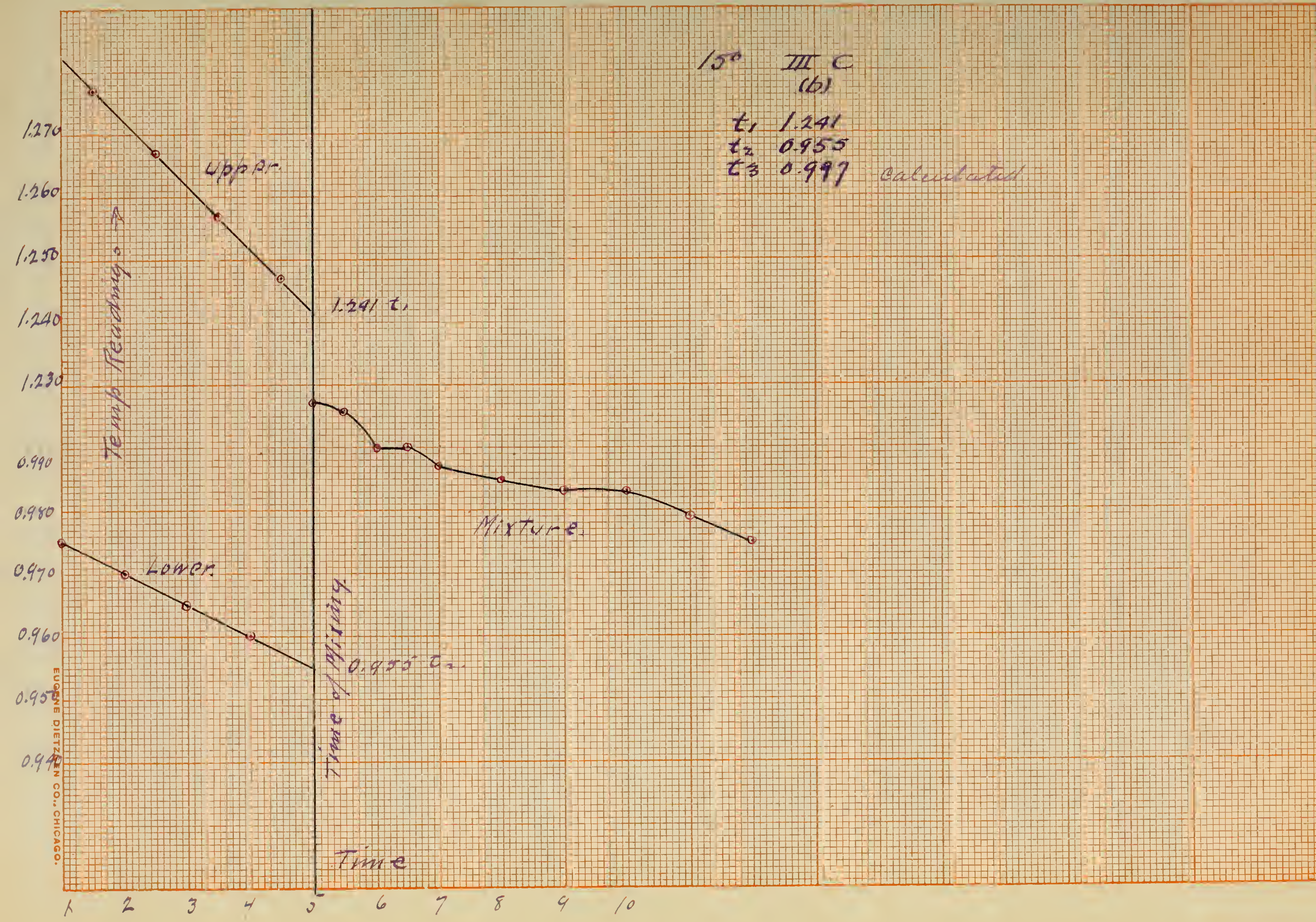
15° III C
(b)
t1 1.241
t2 0.955
t3 0.997 Calculated
Upper.
Lower.
Mixture.
1.241 t1
0.955 t2
Time of Mixing
Time
Temp Reading
1.270
1.260
1.250
1.240
1.230
0.990
0.980
0.970
0.960
1
2
3
4
5
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EUGENE DIETZGEN CO., CHICAGO.

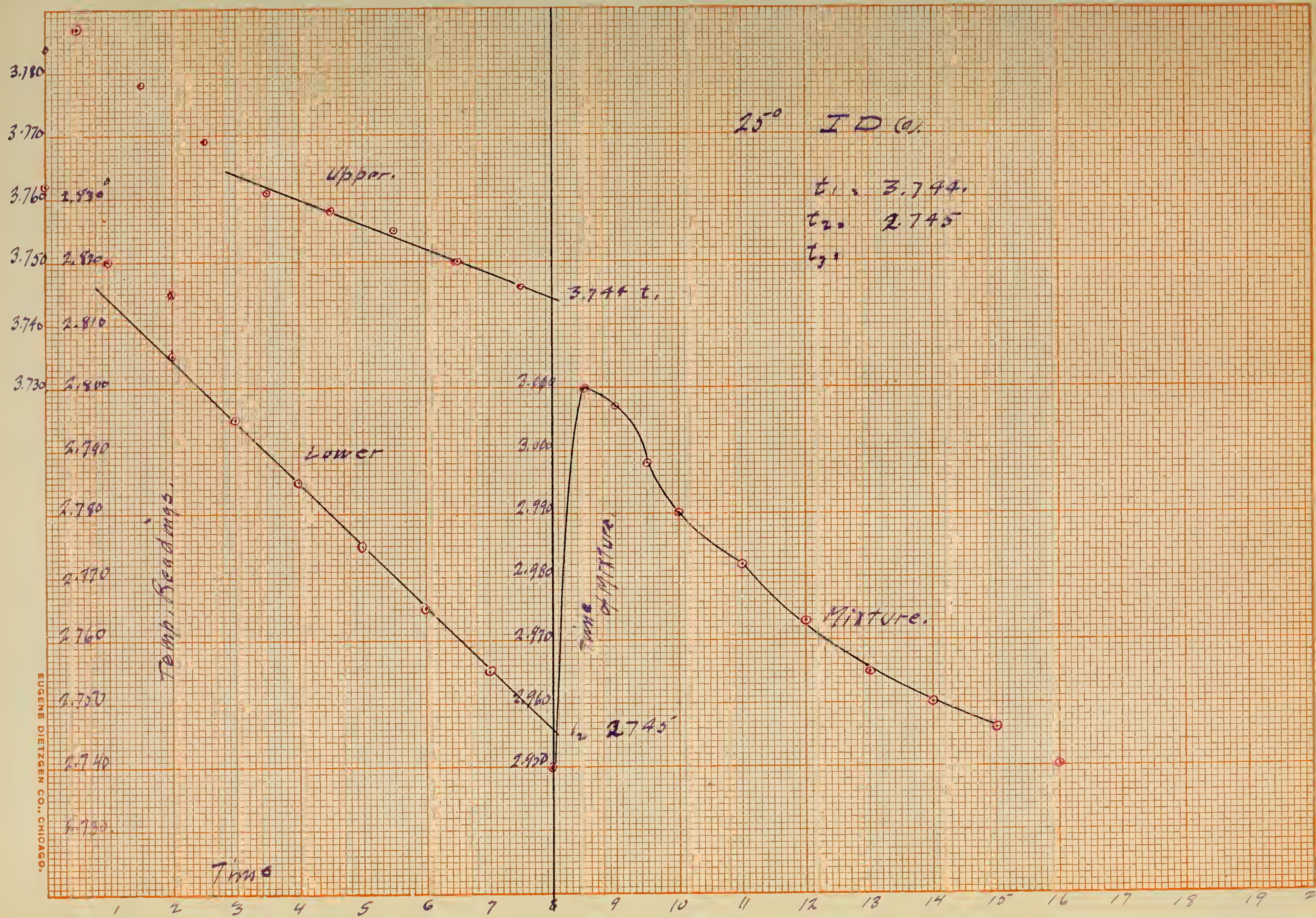
25° Table I D.

500 g Water } Below. Diluted with 200 g water.
171 g Sugar }

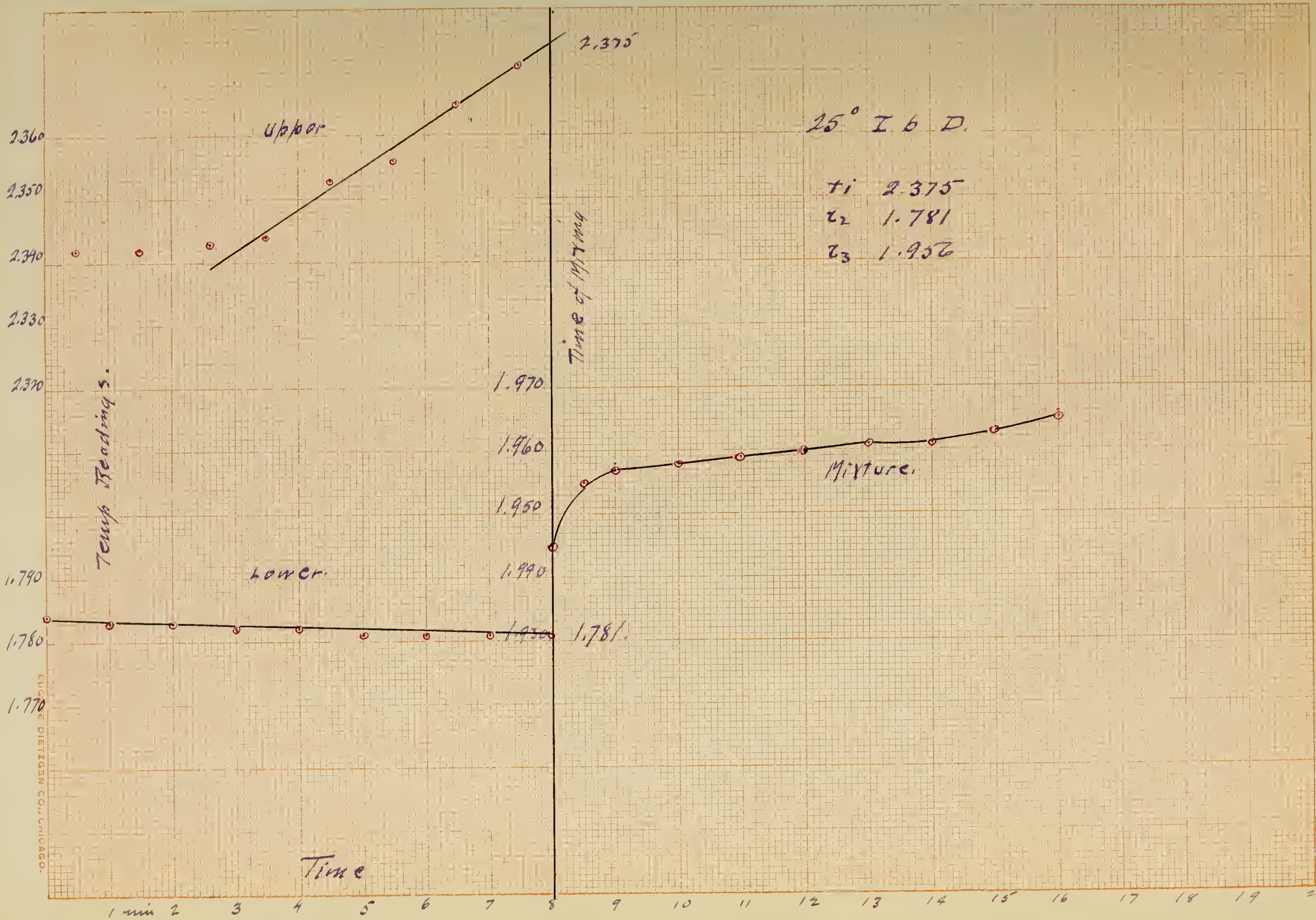
Temperature Readings taken at minute intervals.

(a)		b.	
Upper Flask.	Lower Dewar.	Upper Flask.	Lower Dewar.
3.787° C	2.832° C	2.342° C	1.784° C
3.778° C	2.820° "	2.342° C	1.783° "
3.769° C	2.805° "	2.343° C	1.783° "
3.761° "	2.795° "	2.349° "	1.782° "
3.758° "	2.785° "	2.353° "	1.782° "
3.754° "	2.775° "	2.356° "	1.781° "
3.750° "	2.765° "	2.365° "	1.781° "
3.746° "	2.756° "	2.371° "	1.781° "

Mixture.		Mixture.	
½ min int. Readings	2.950° C	½ min. Readings	1.945° C
	3.010° "		1.955° "
	3.007° "		1.957° "
	2.998° "		1.958° "
	2.990° "		1.959° "
	2.982° "		1.960° "
	2.973° "		1.961° "
	2.965° "		1.962° "
	2.960° "		1.964° "
	2.956° "		1.965° "
	2.949° "		



EUGENE DIETZGEN CO., CHICAGO.



25° I b D.
t_1 2.375
t_2 1.781
t_3 1.956
Upper
Lower
Mixture.
Time of Mixing
Temp Readings.
Time
2.375
1.781
2.360
2.350
2.340
2.330
2.320
1.790
1.780
1.770
1.970
1.960
1.950
1.940
1 min
2
3
4
5
6
7
8
9
10
11
12
13
14
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16
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19
20
EUGENE DIETZGEN CO., CHICAGO.

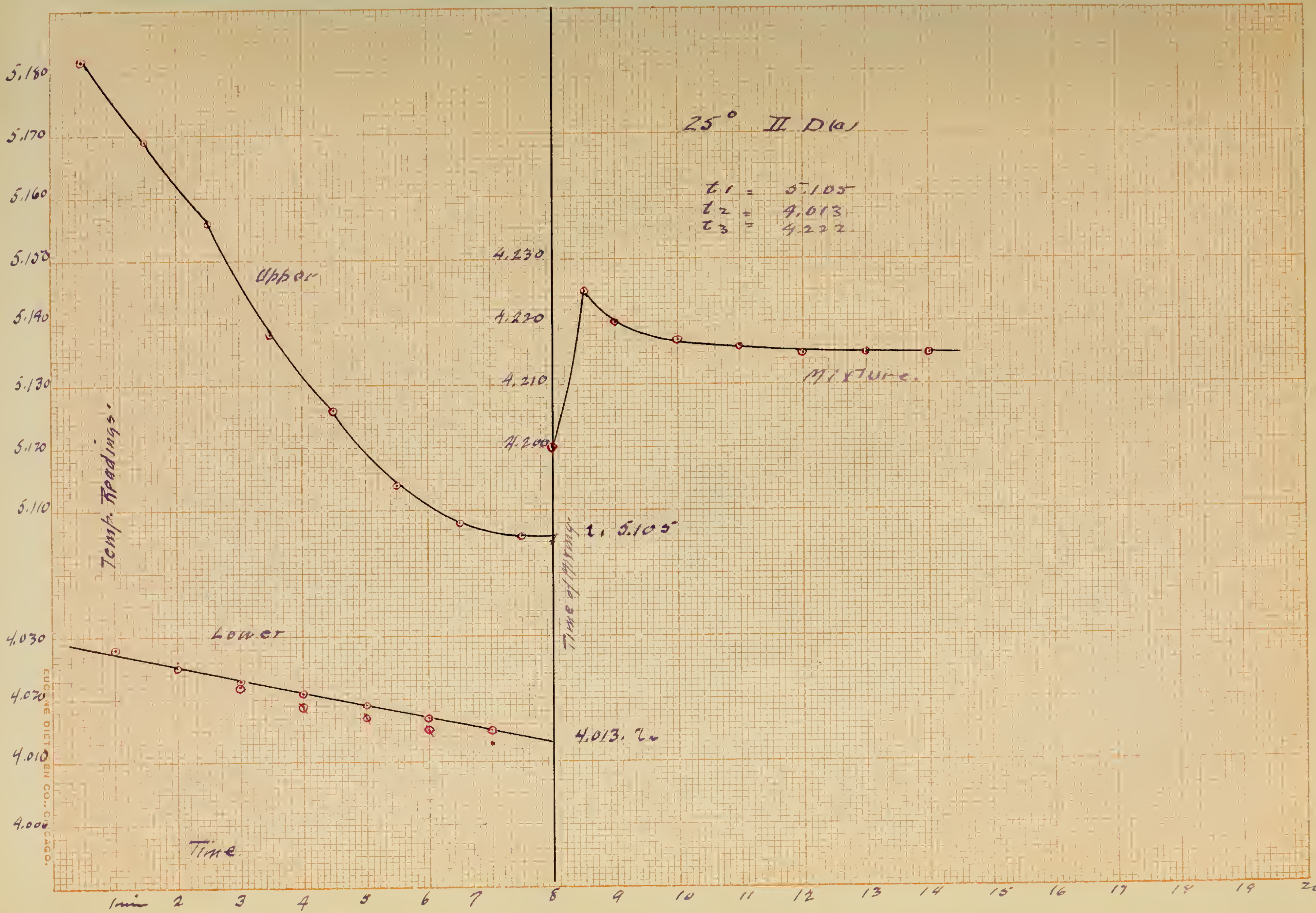
25° Table. II D.

550 g Water }
188.1 " Sugar } Below. Diluted with 150 g water.

(a)

Upper Flask.	Lower Dewar.
5.183° C	4.038° C
5.169° "	4.028° "
5.156° "	4.025° "
5.138° "	4.023° "
5.125° "	4.021° "
5.119° "	4.019° "
5.108° "	4.017° "
5.106.	4.015° "

Mixture. $\left.\frac{1}{2}\text{ min.}\right\{$ 4.200°C
4.225°C
4.220° "
4.218° "
4.217° "
4.216° "
4.216 "


25° II D(a)
t_1 = 5.105
t_2 = 4.013
t_3 = 4.222
Temp. Readings.
Upper
Lower
Mixture.
Time of Mixing.
t_1 5.105
4.013. t_2
Time
1 min 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
5.180 5.170 5.160 5.150 5.140 5.130 5.120 5.110
4.230 4.220 4.210 4.200
4.030 4.020 4.010 4.000
EUGENE DIETZGEN CO., CHICAGO.